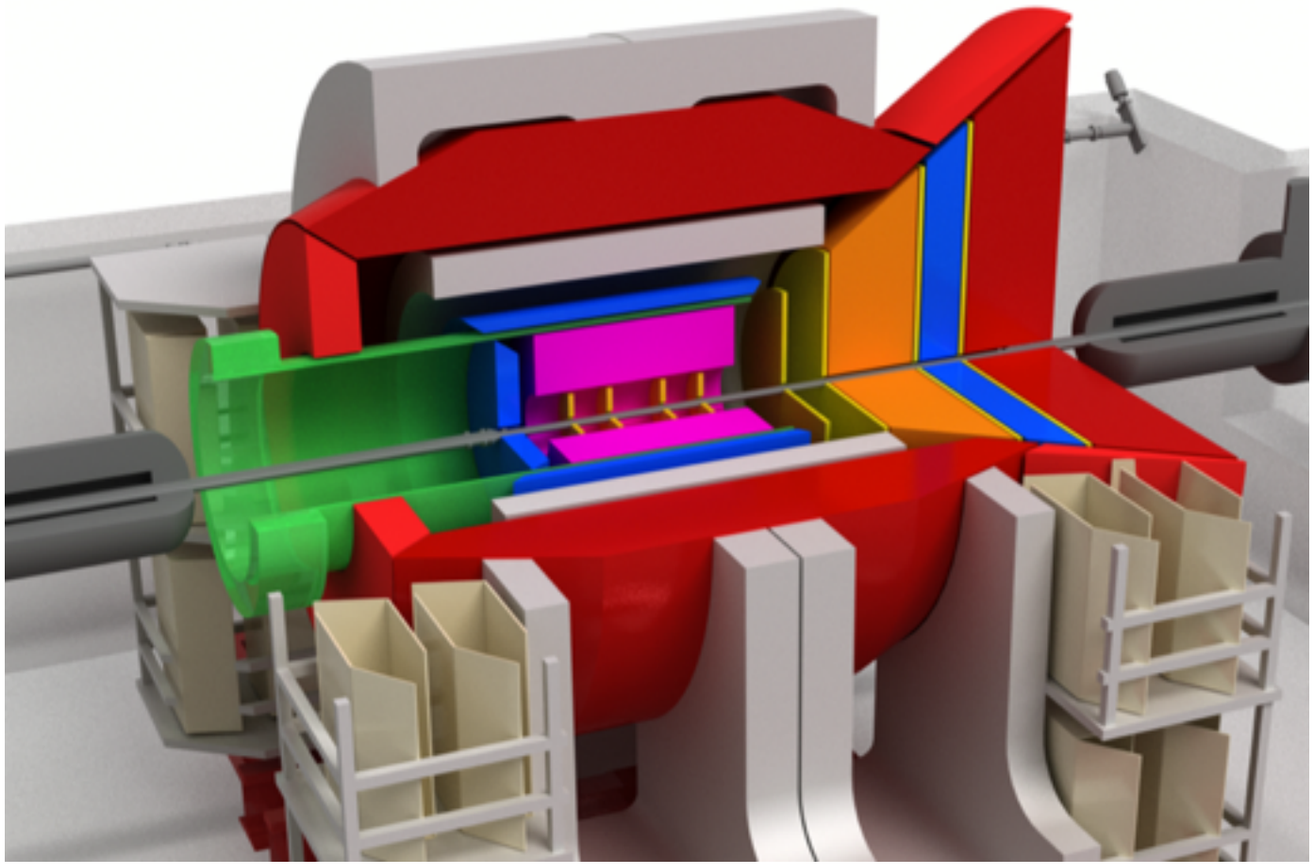
Stony Brook University

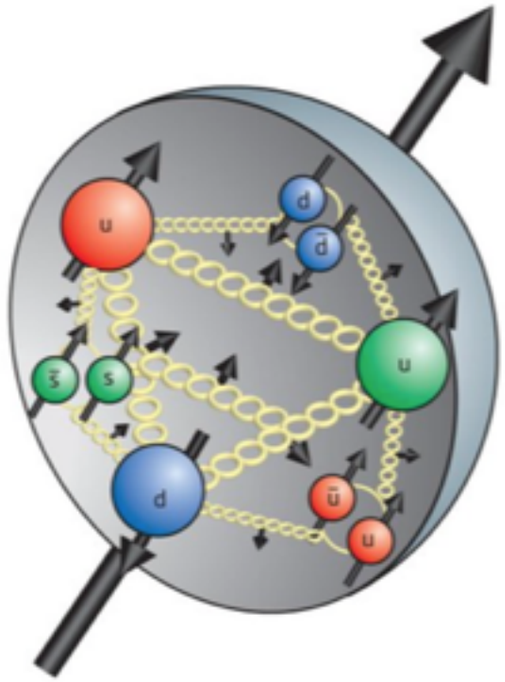


EIC Detector with BaBar Solenoid: Simulations, Status and Plans

Nils Feege

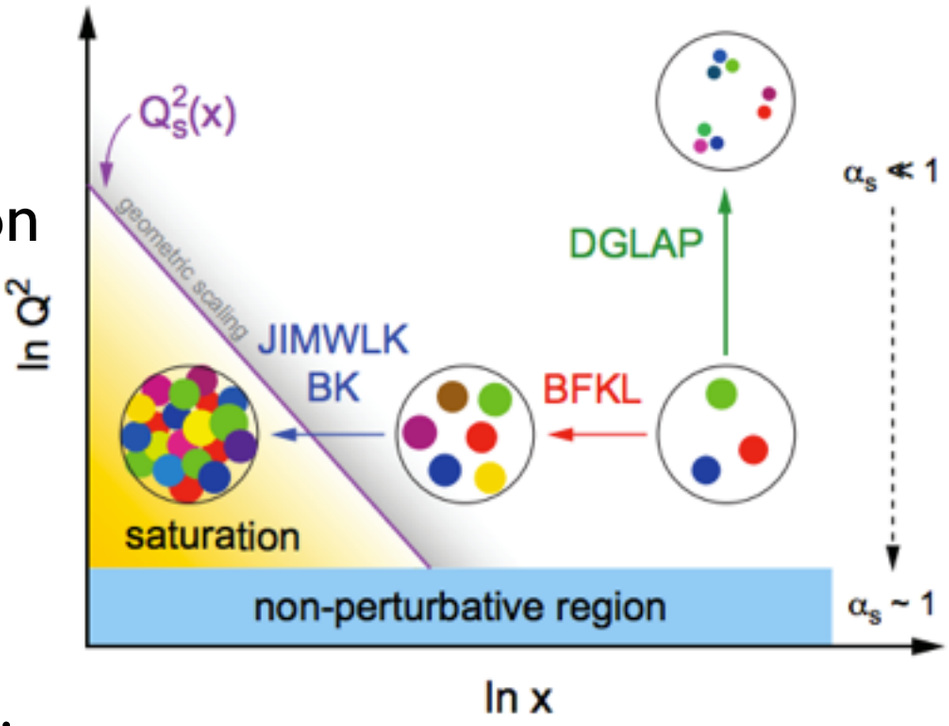
fsPHENIX Worshop at Stony Brook, March 1, 2015

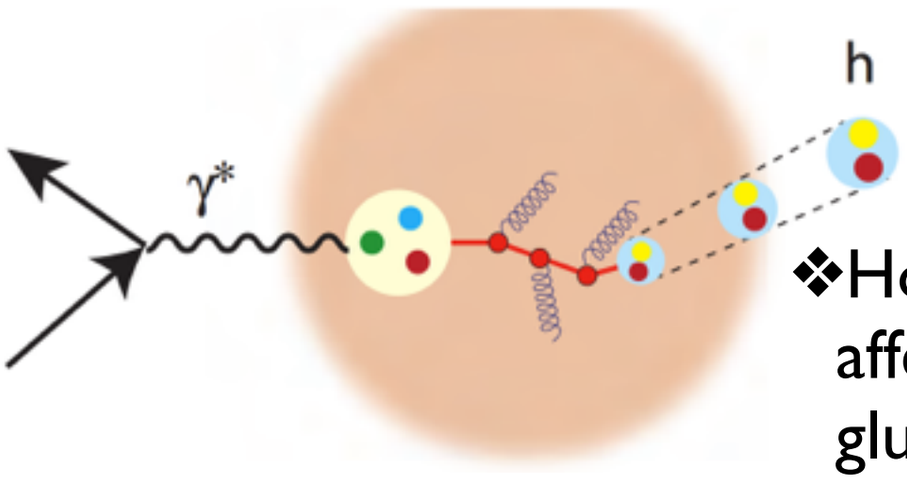
Questions Addressed by the Electron Ion Collider



❖How are the sea quarks and gluons, and their spins, distributed in space and momentum inside the nucleon?

❖Where does the saturation of gluon densities set in?





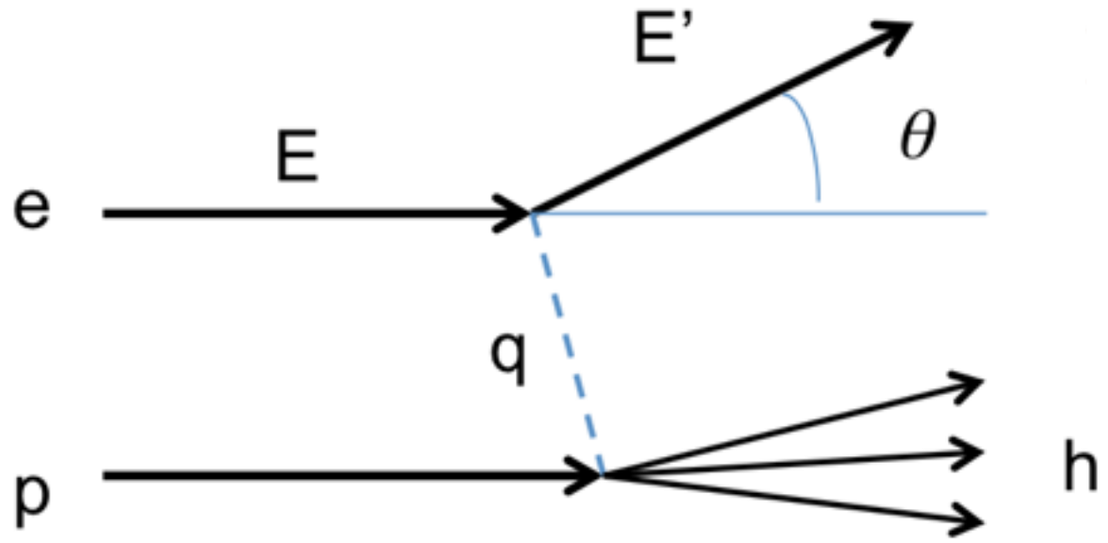
❖How does the nuclear environment affect the distribution of quarks and gluons and their interactions in nuclei?

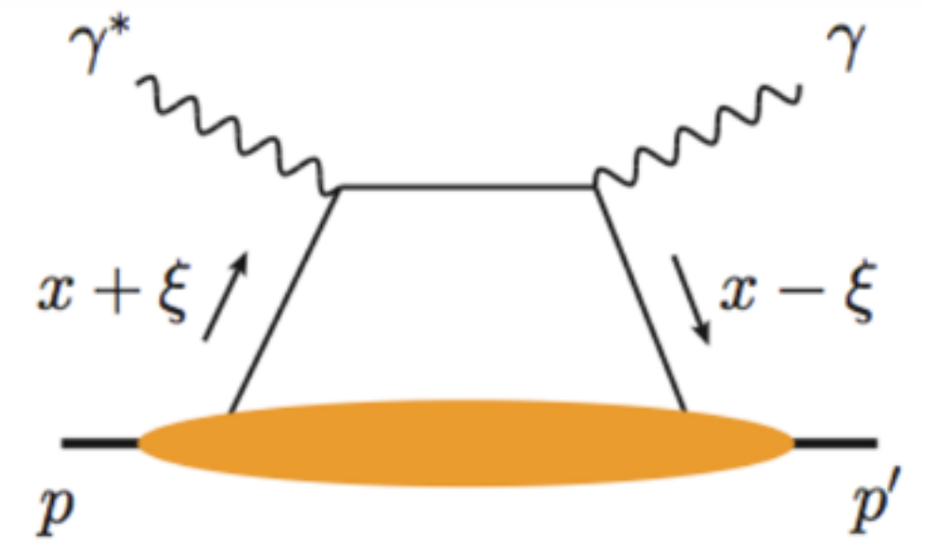
arXiv:1212.1701

EIC Detector Concept

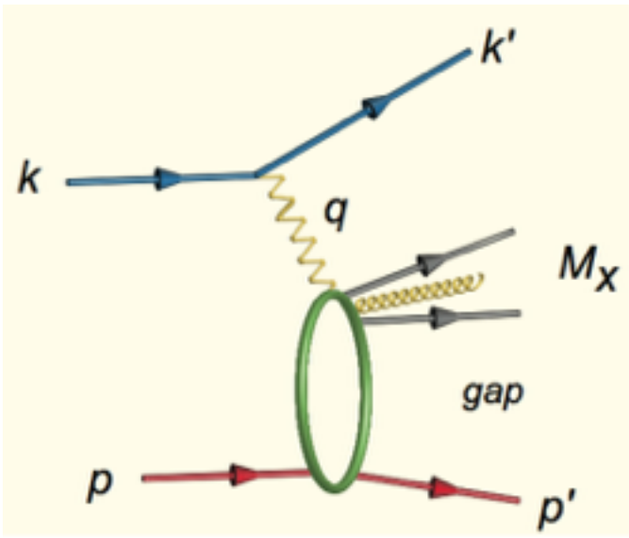
❖Inclusive DIS, scattered electron

❖Semi-inclusive DIS, hadron ID



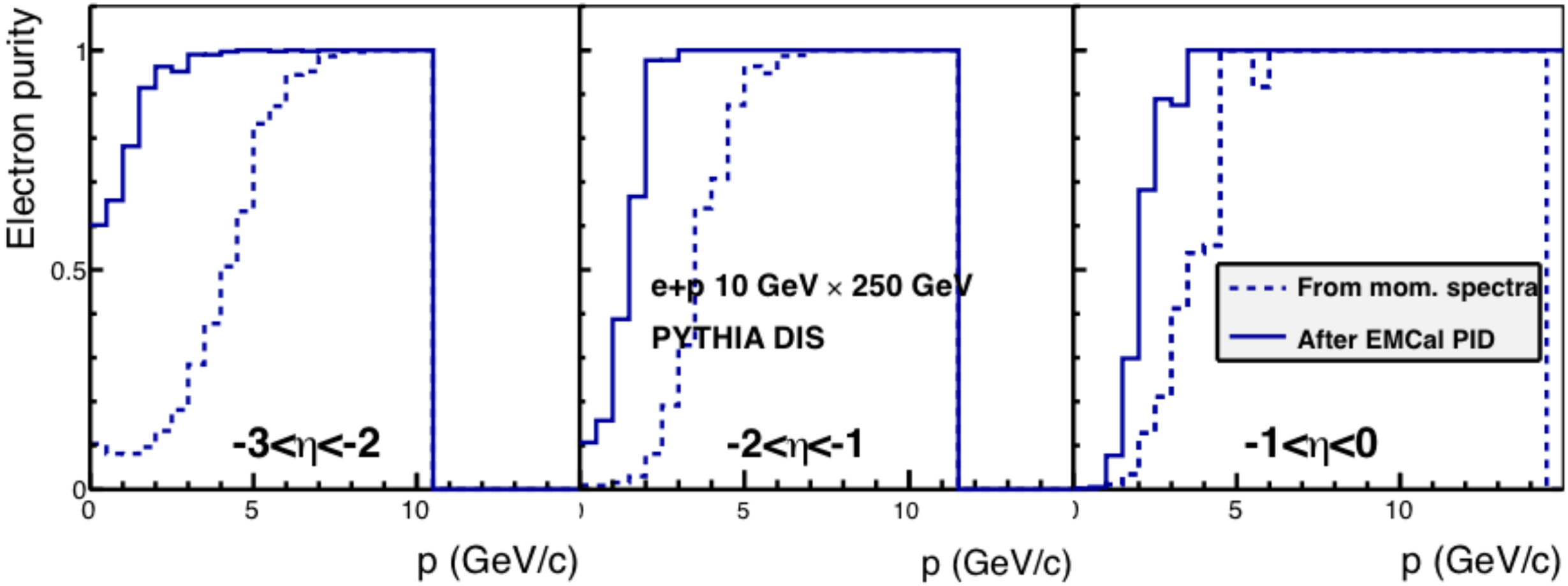


❖ Exclusive DIS (DVCS etc.)



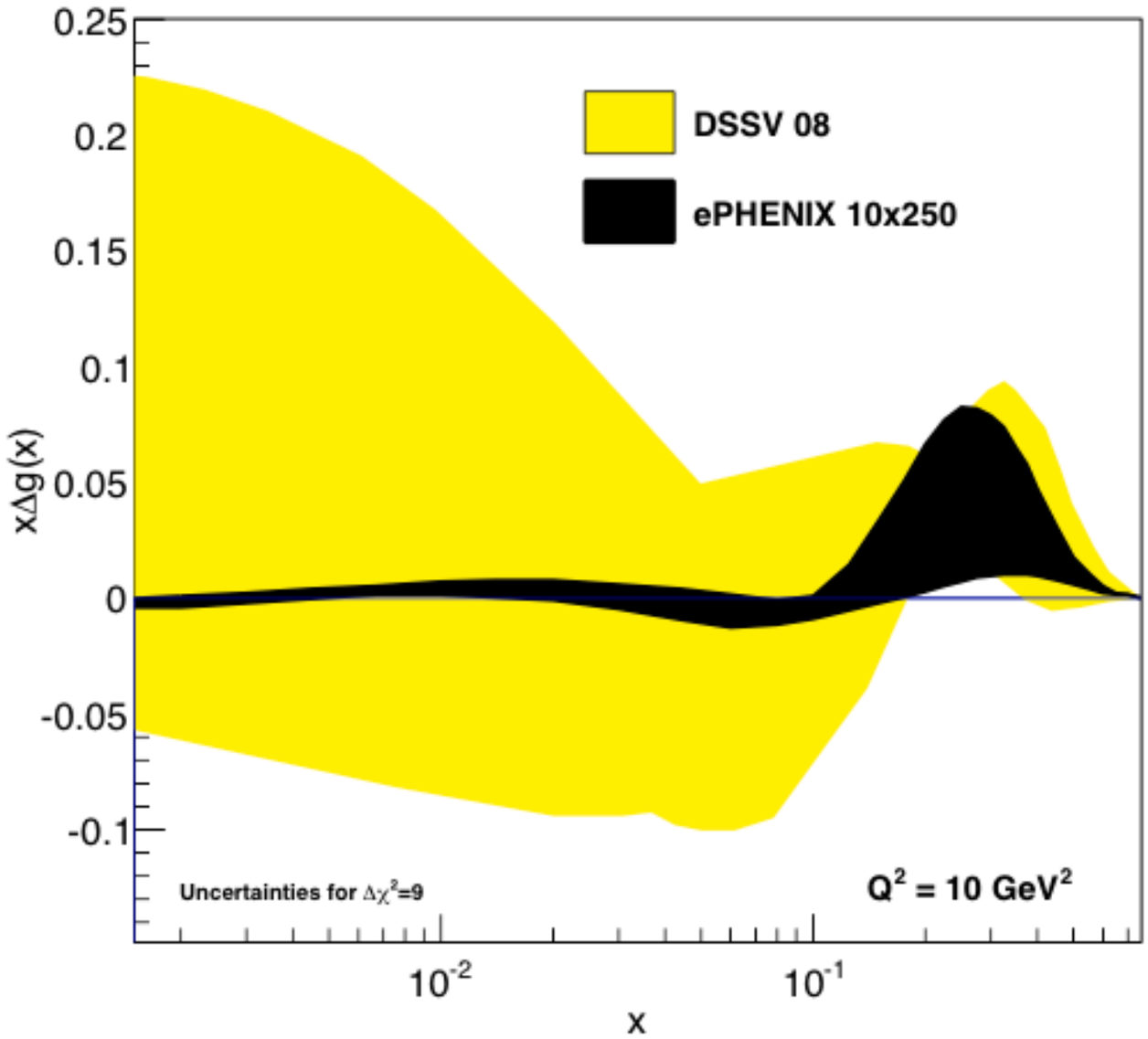
❖Diffractive

Goal: Quantify Calorimeter e-pi Separation with GEANT4 Simulation



(arXiv:1402.1209v1): parametrization

Goal: Update Projected Uncertainty on Longitudinal Gluon Spin

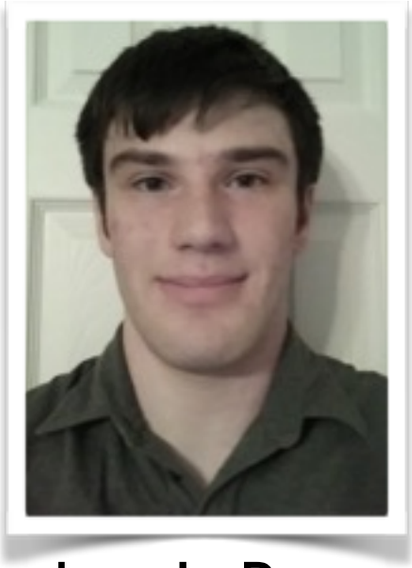


with updated simulations / detector design

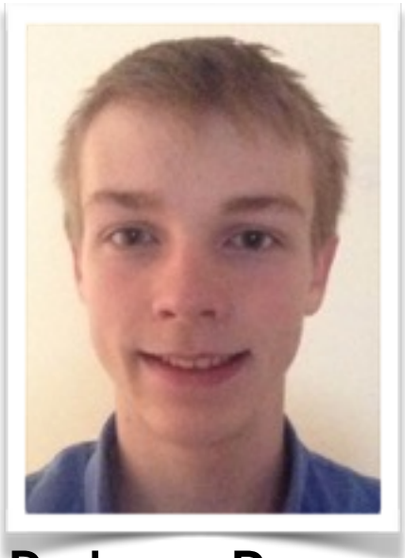
(arXiv:1402.1209v1)

Stony Brook Students

Dhananjay Ravikumar



Joshua LaBounty



Robert Bruce

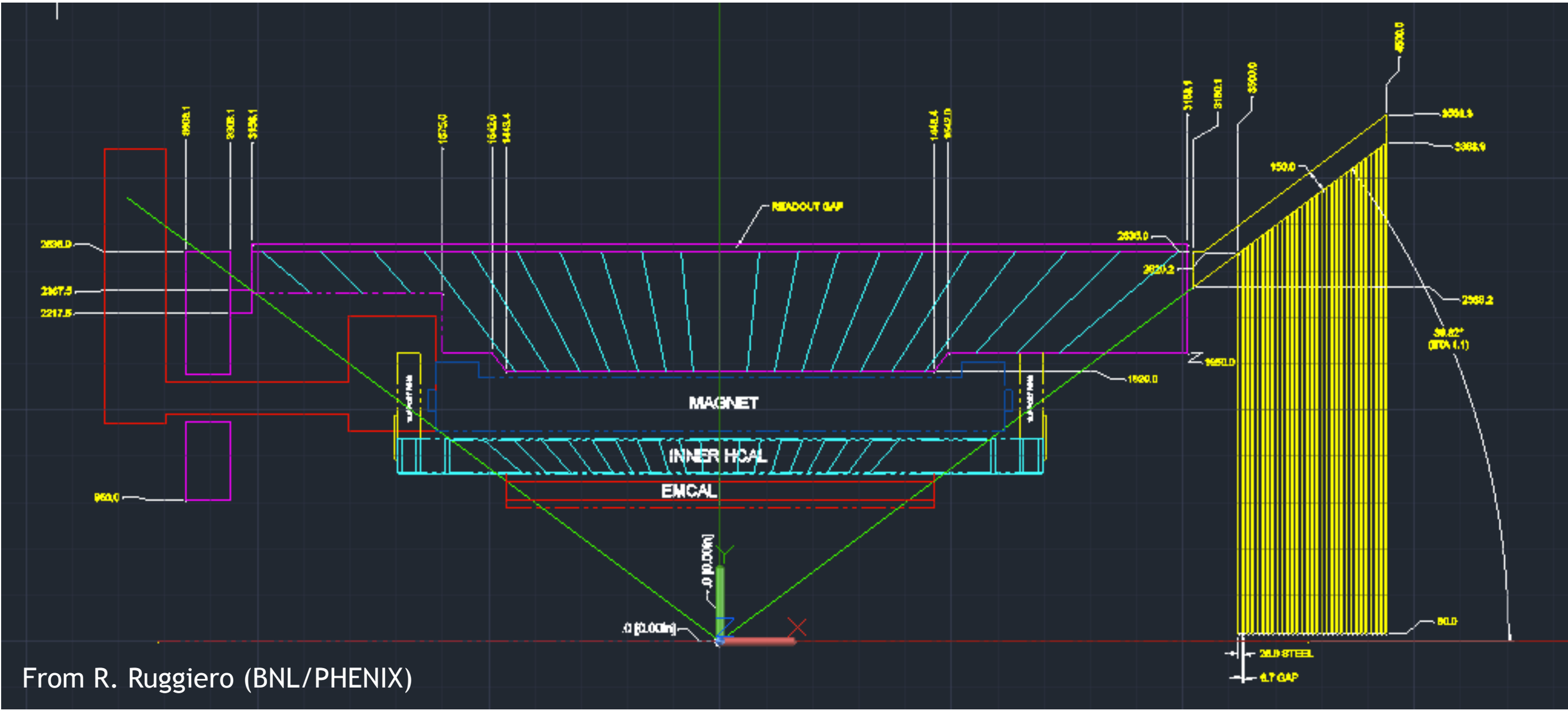
Tiffany LaByer

Kyle Capobianco-Hogan

Thomas Krahulik

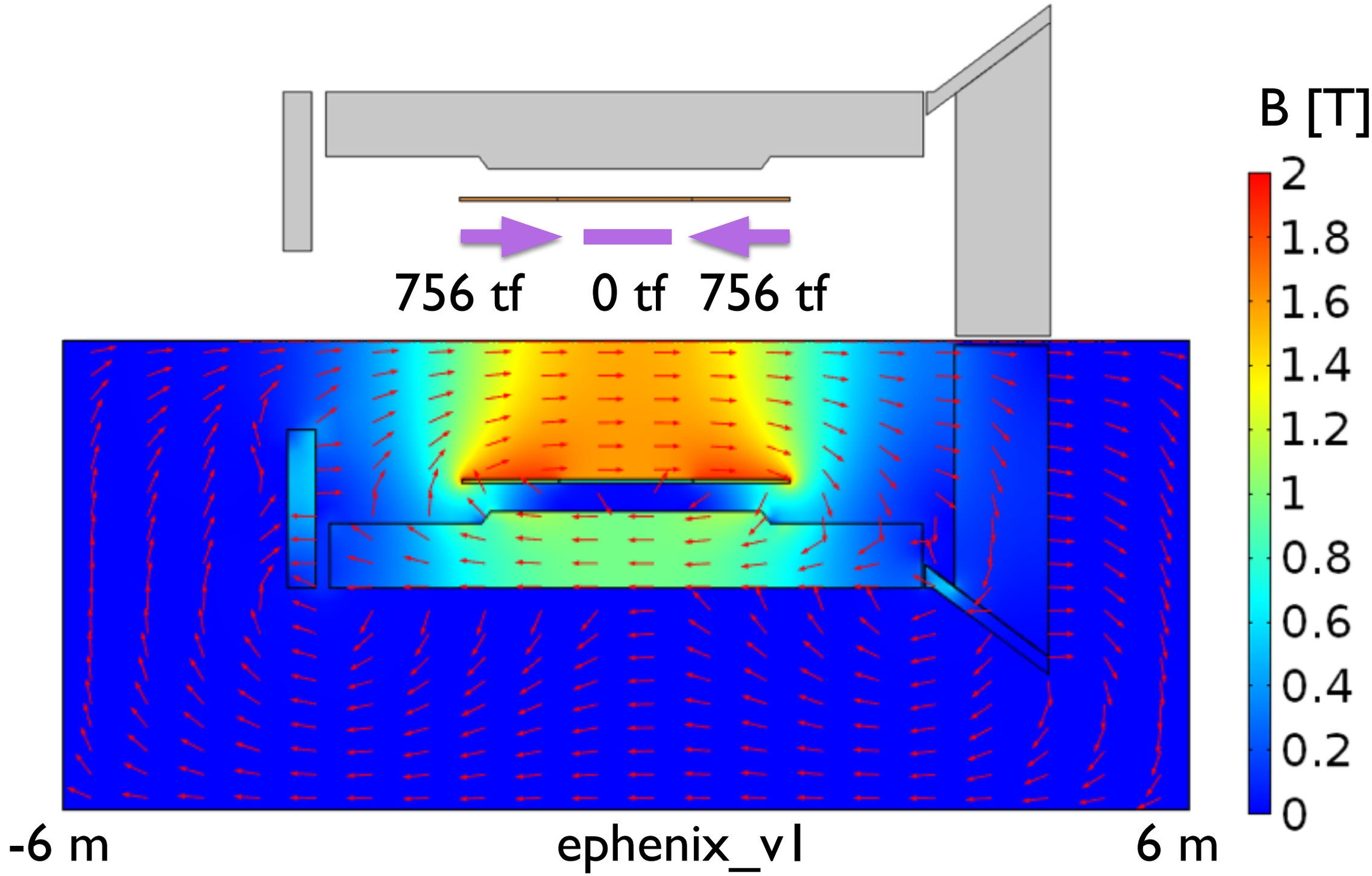
- COMSOL: Magnet Simulation
- GEANT4: Forward Calorimeter
- GEANT4: Forward Gas RICH

An updated mechanical design for EIC Detector / fsPHENIX

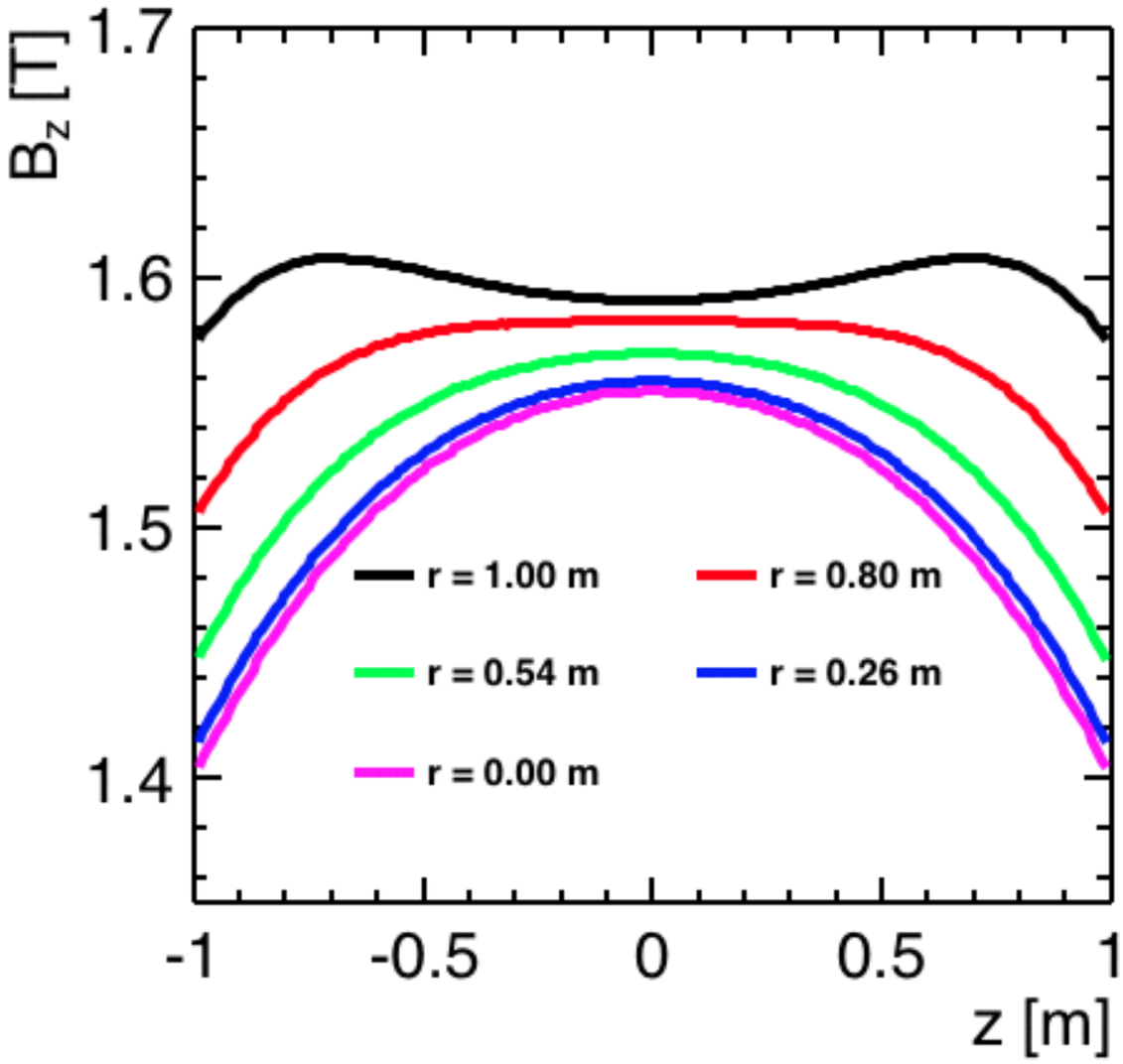


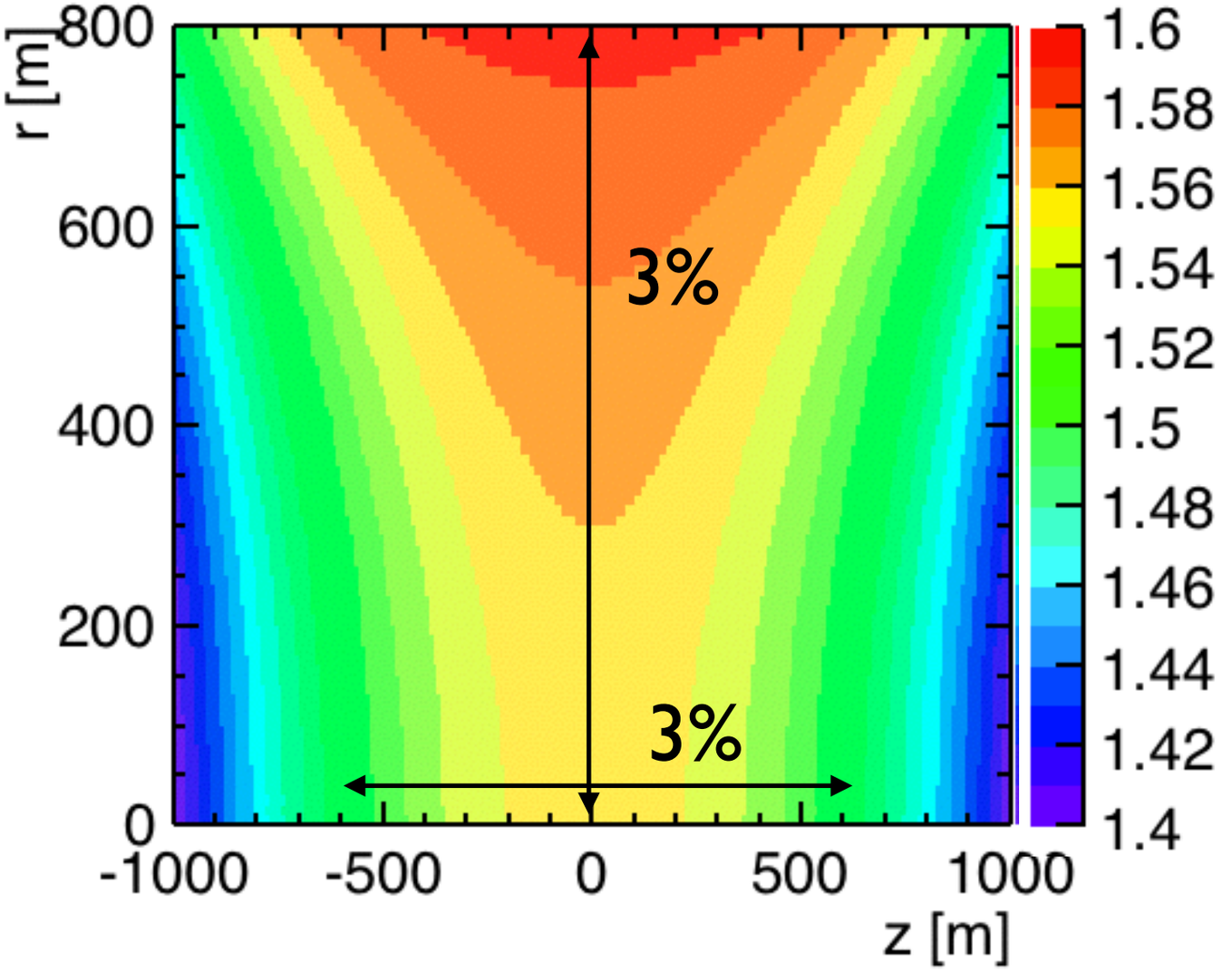
From R. Ruggiero (BNL/PHENIX)

Magnetic field in COMSOL



Magnetic field in COMSOL





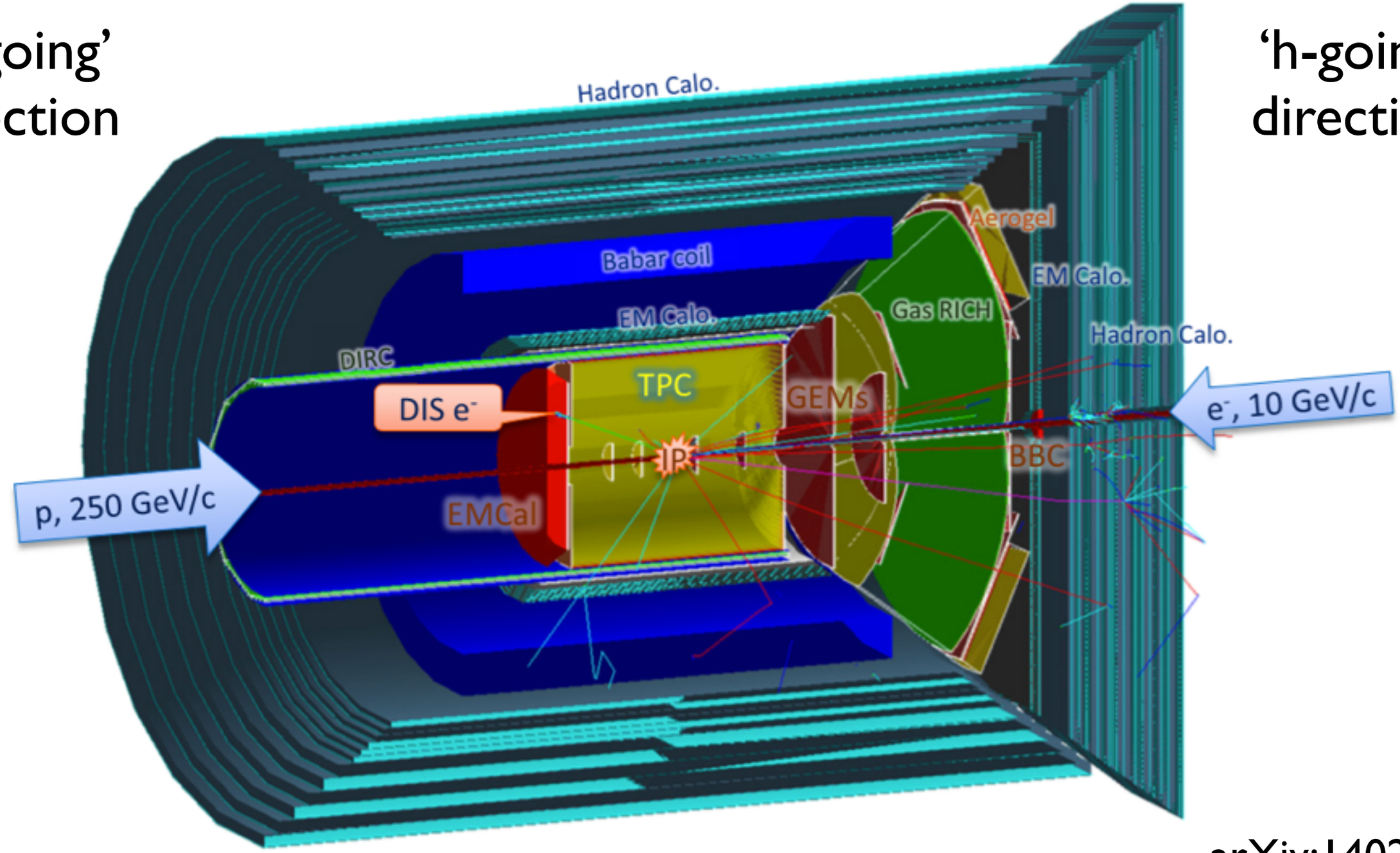
Next Steps

- Cross checking the bare Babar coil COMSOL / POISSON
- Implement Hipperco-50 piston
- Evaluate field uniformity in the TPC region
- Evaluate RICH field distortion
- Reproduce the internal stress of the BaBar coil in the BaBar yoke (~380T)

Detector in GEANT4: All physical detector volumes (materials) are implemented (LOI design)

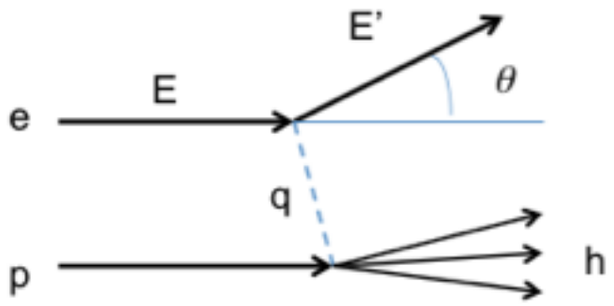
‘e-going’ direction

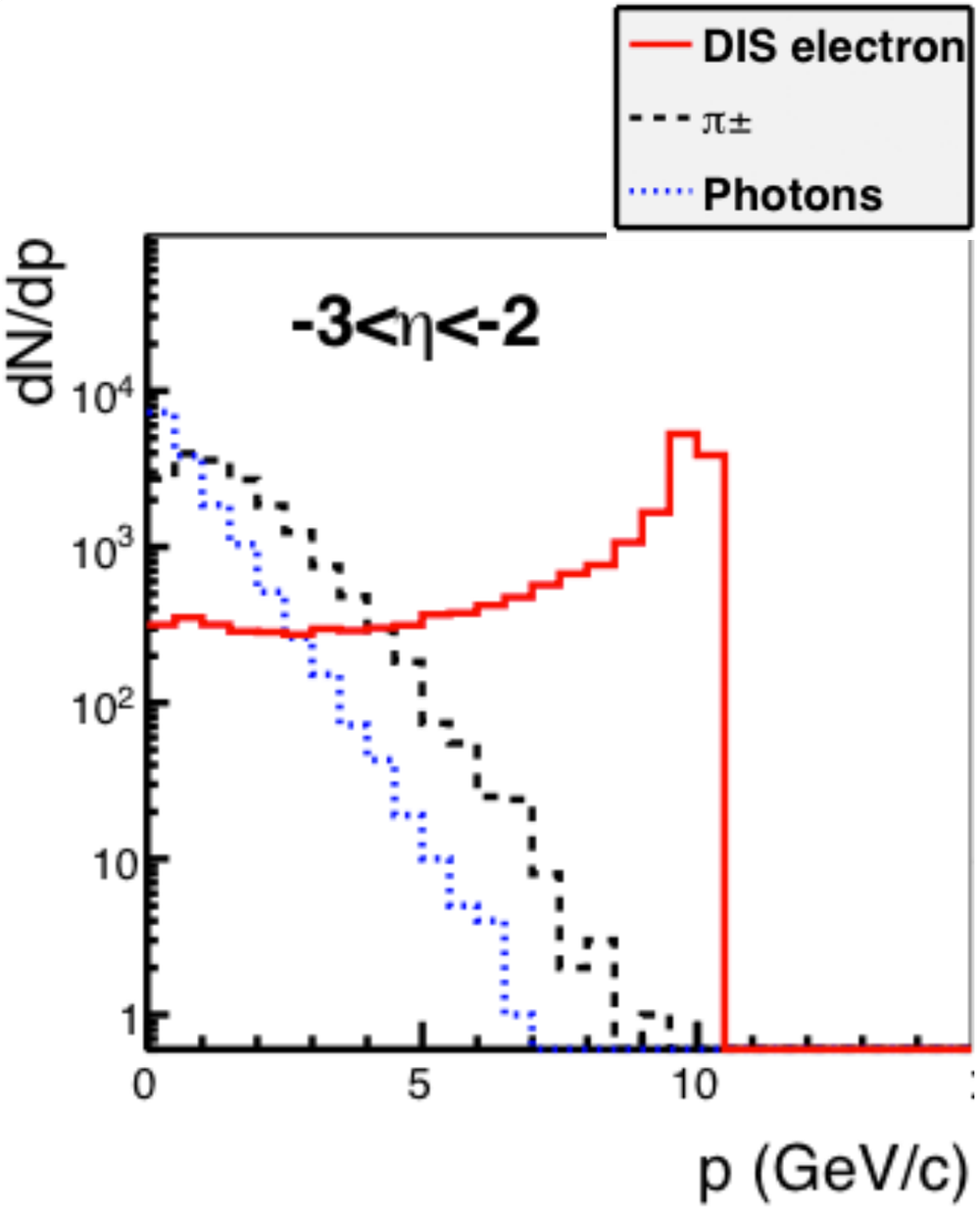
‘h-going’ direction



arXiv:1402.1209

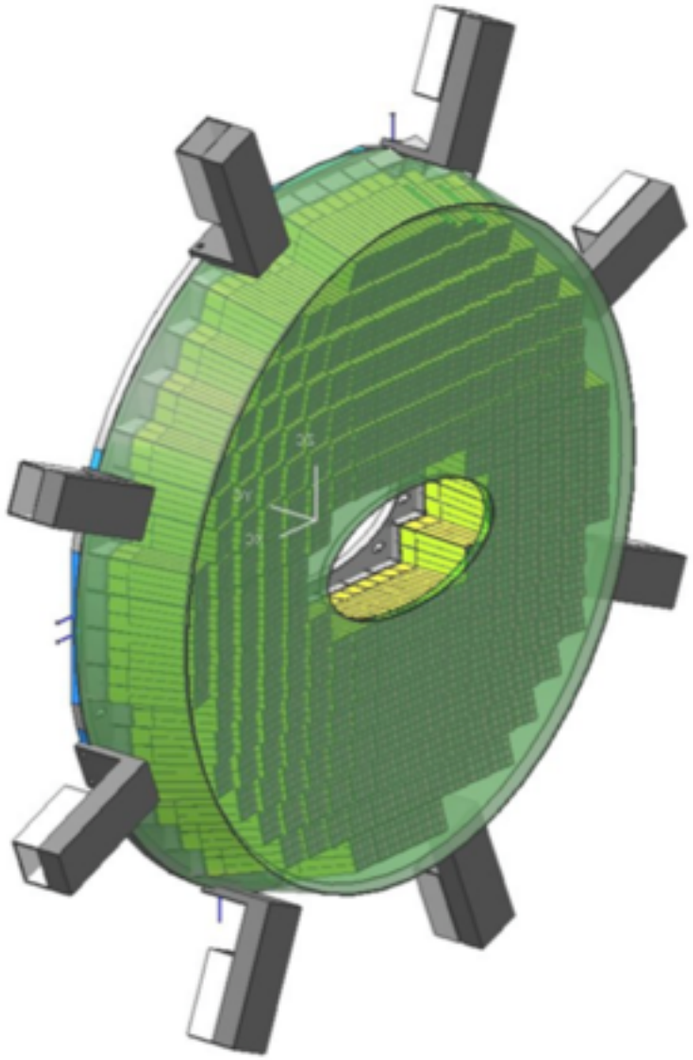
DIS Electron Measurement



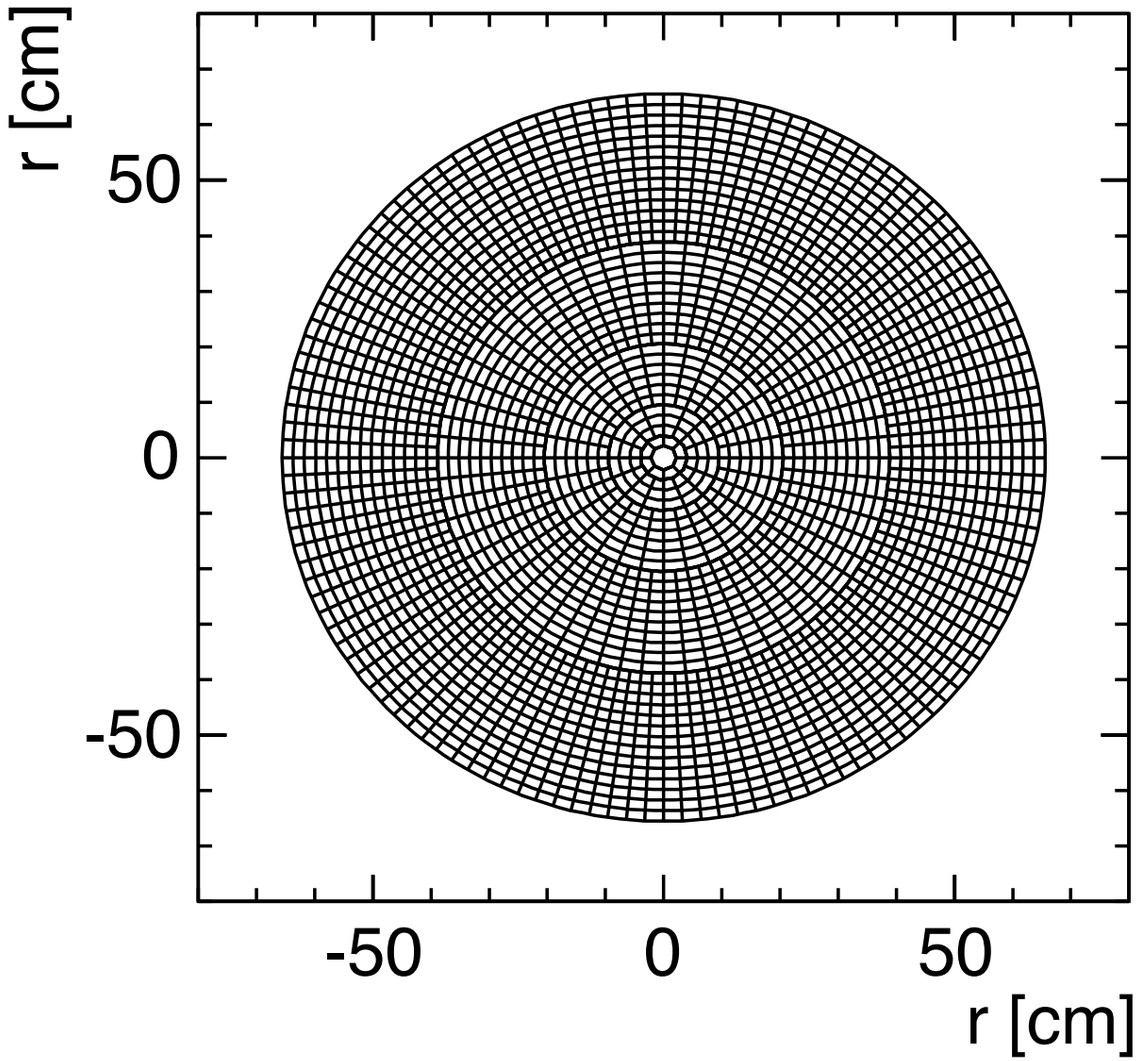


Calorimeter in e-going Direction

Lead-tungstate (PWO): 1.5%/$\sqrt{E}$ energy, 3mm/$\sqrt{E}$ position resolution

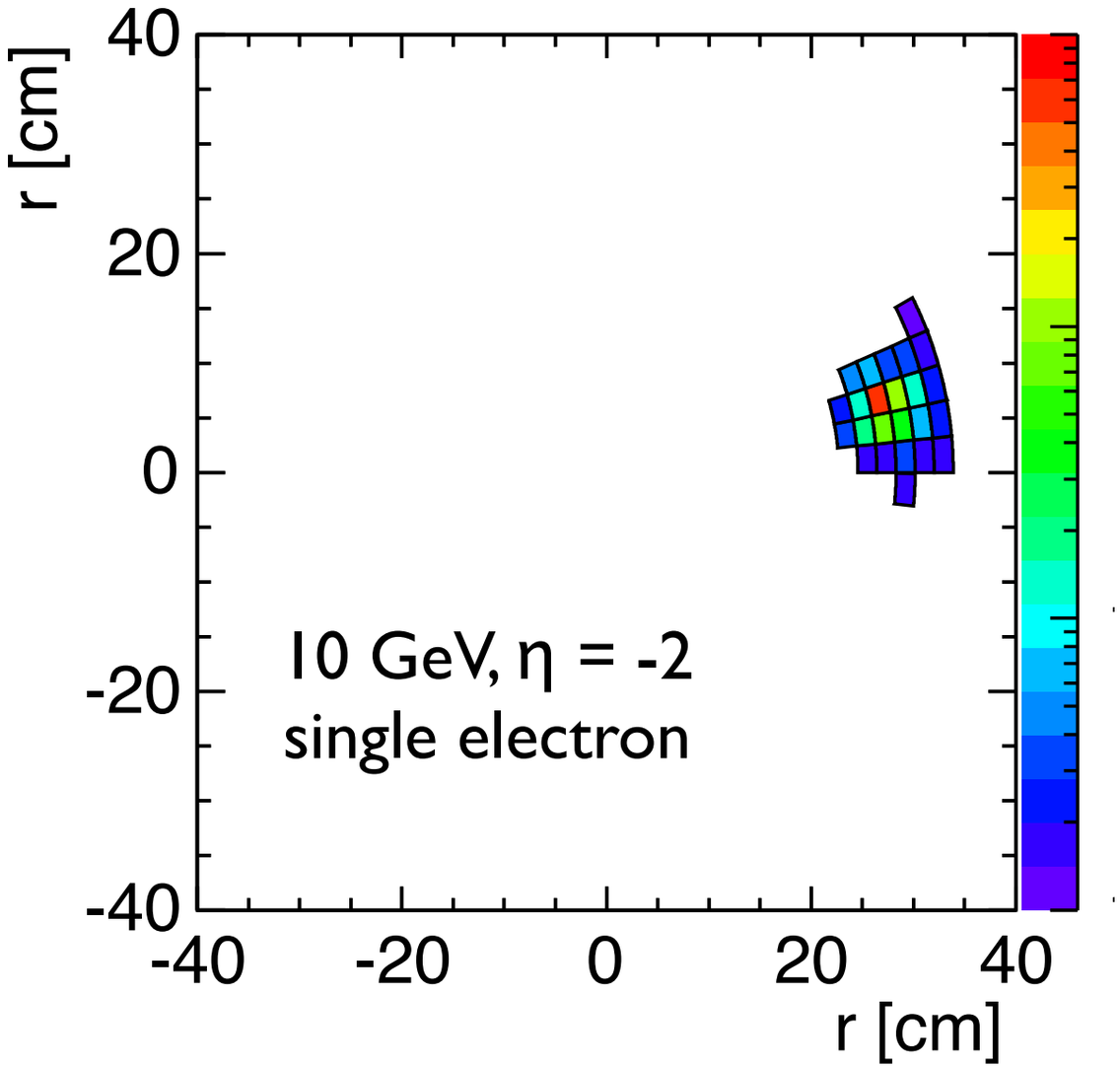


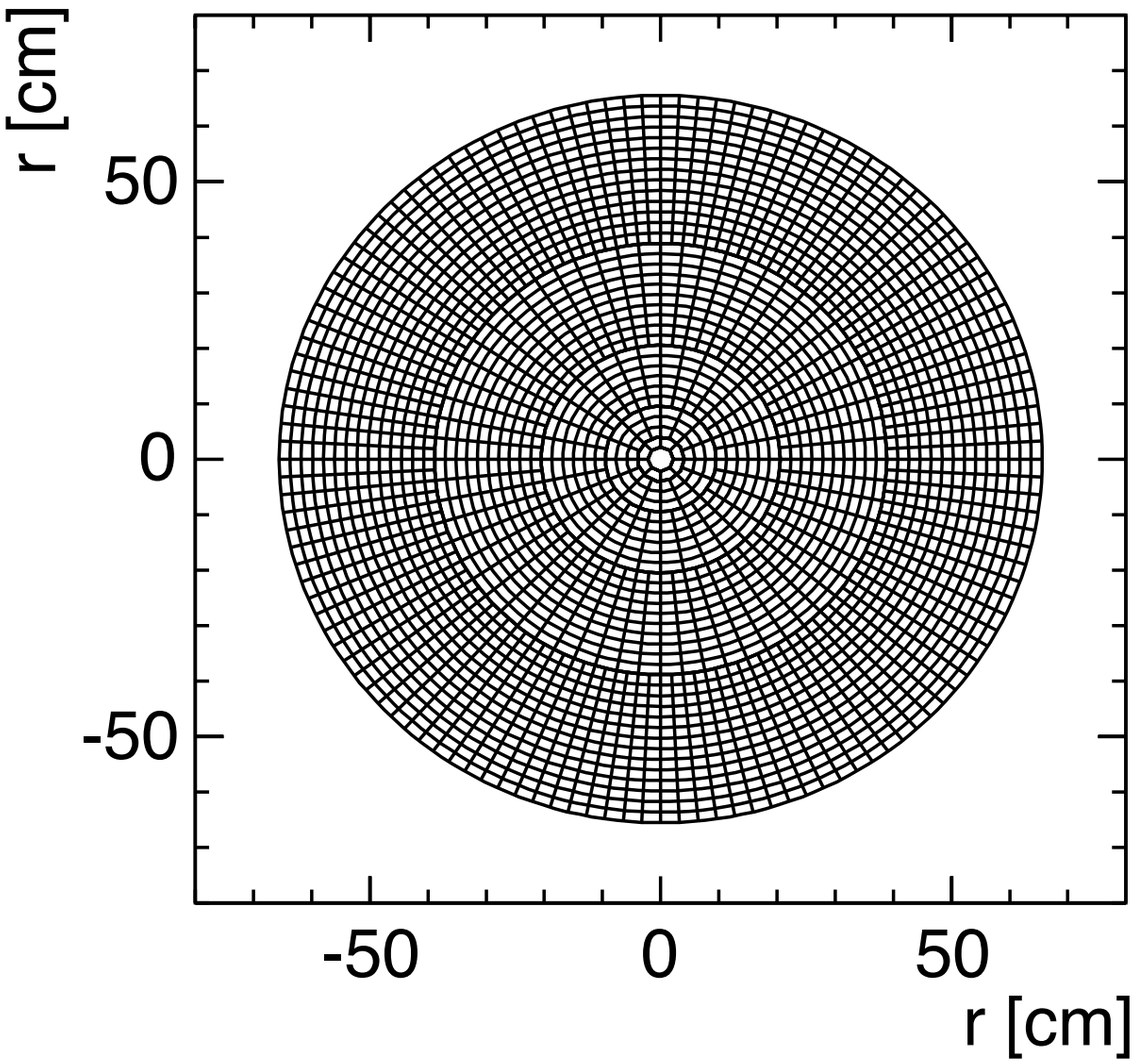
PANDA-like design (arXiv:0810.1216):
~5000 Crystals (~2x2 cm)



Current segmentation in Geant4:
2680 Tower (1.8 x 1.5 cm … 1.8 x 4 cm)

Calorimeter in e-going Direction: Sanity Check





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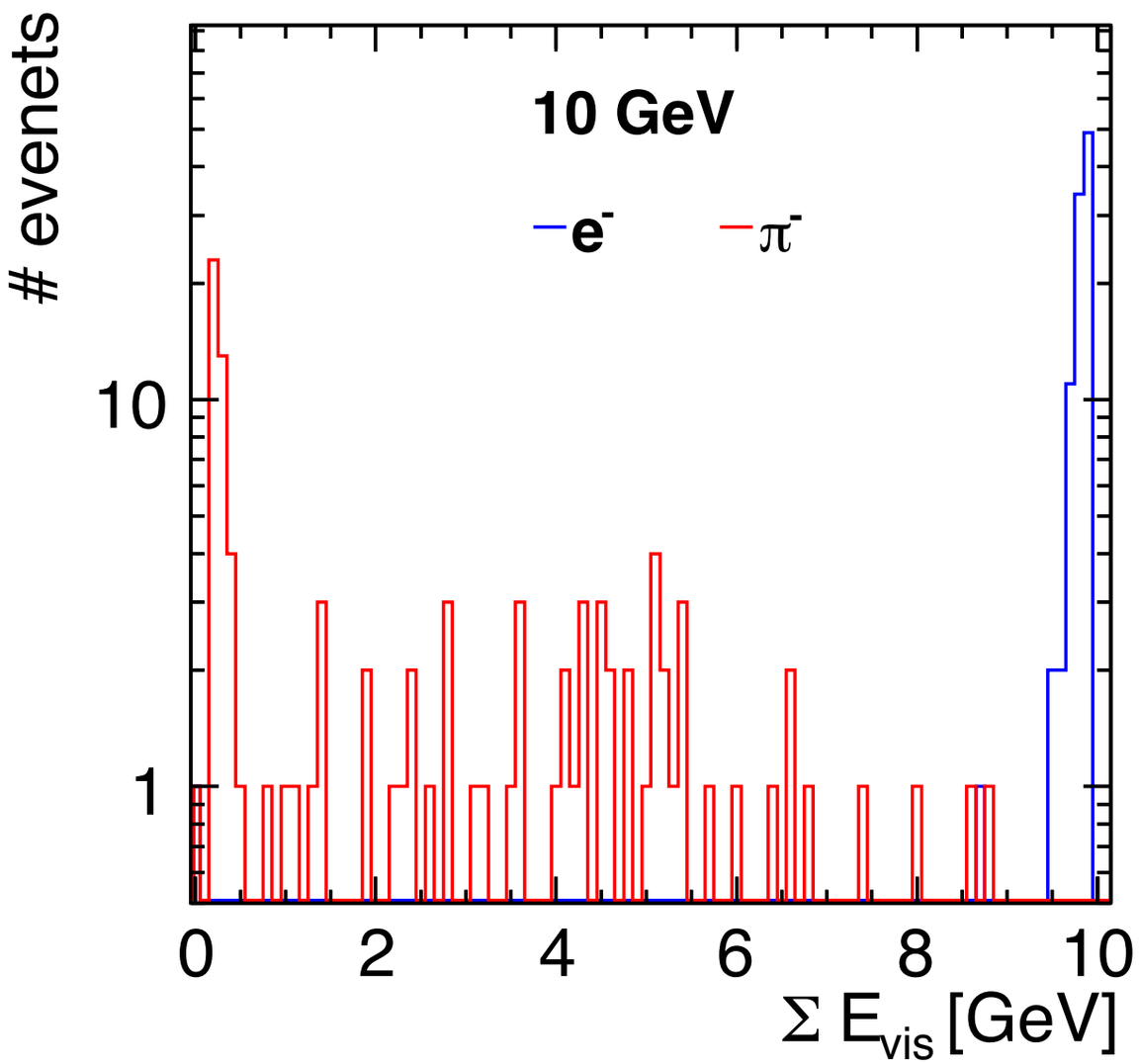
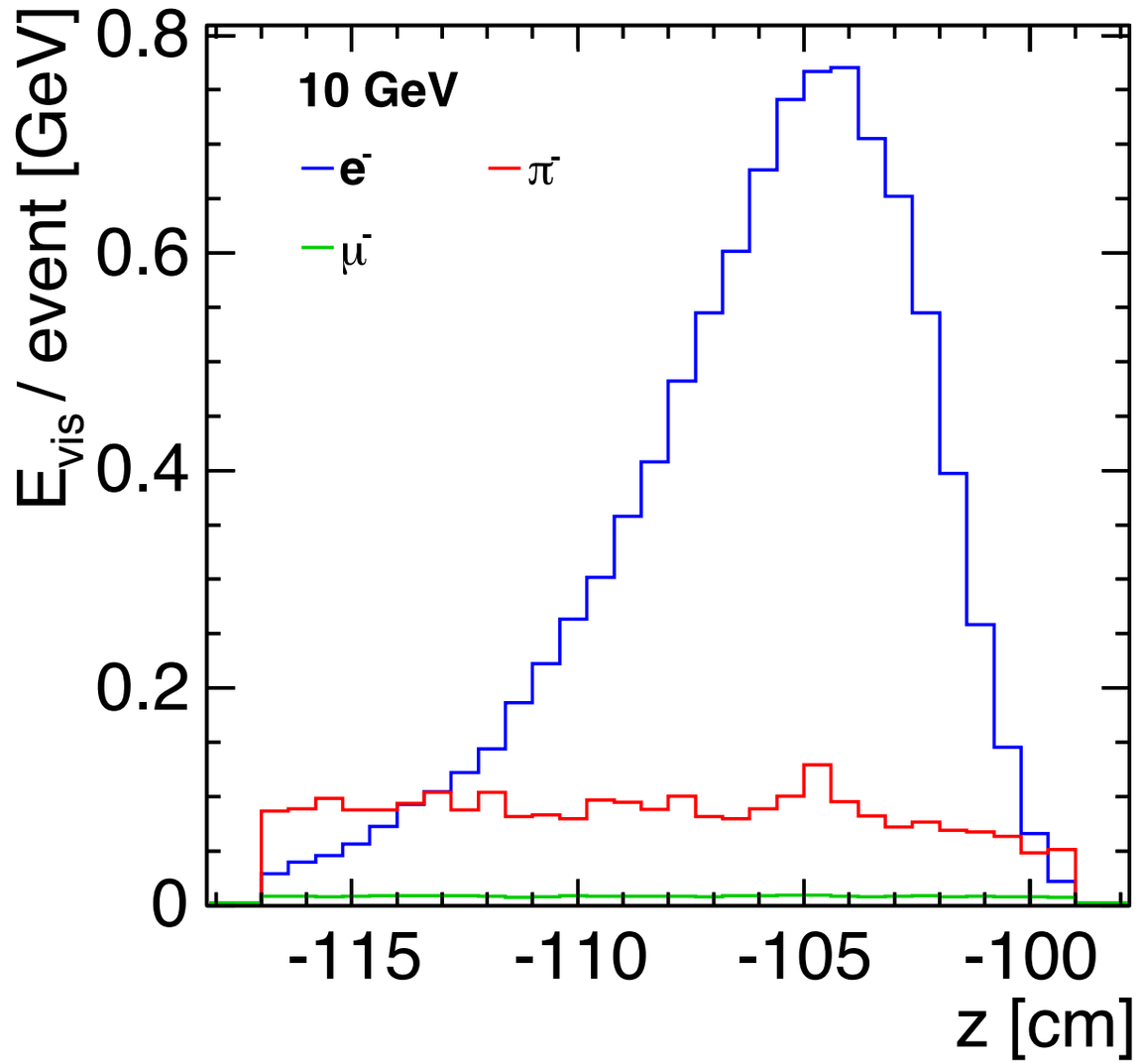
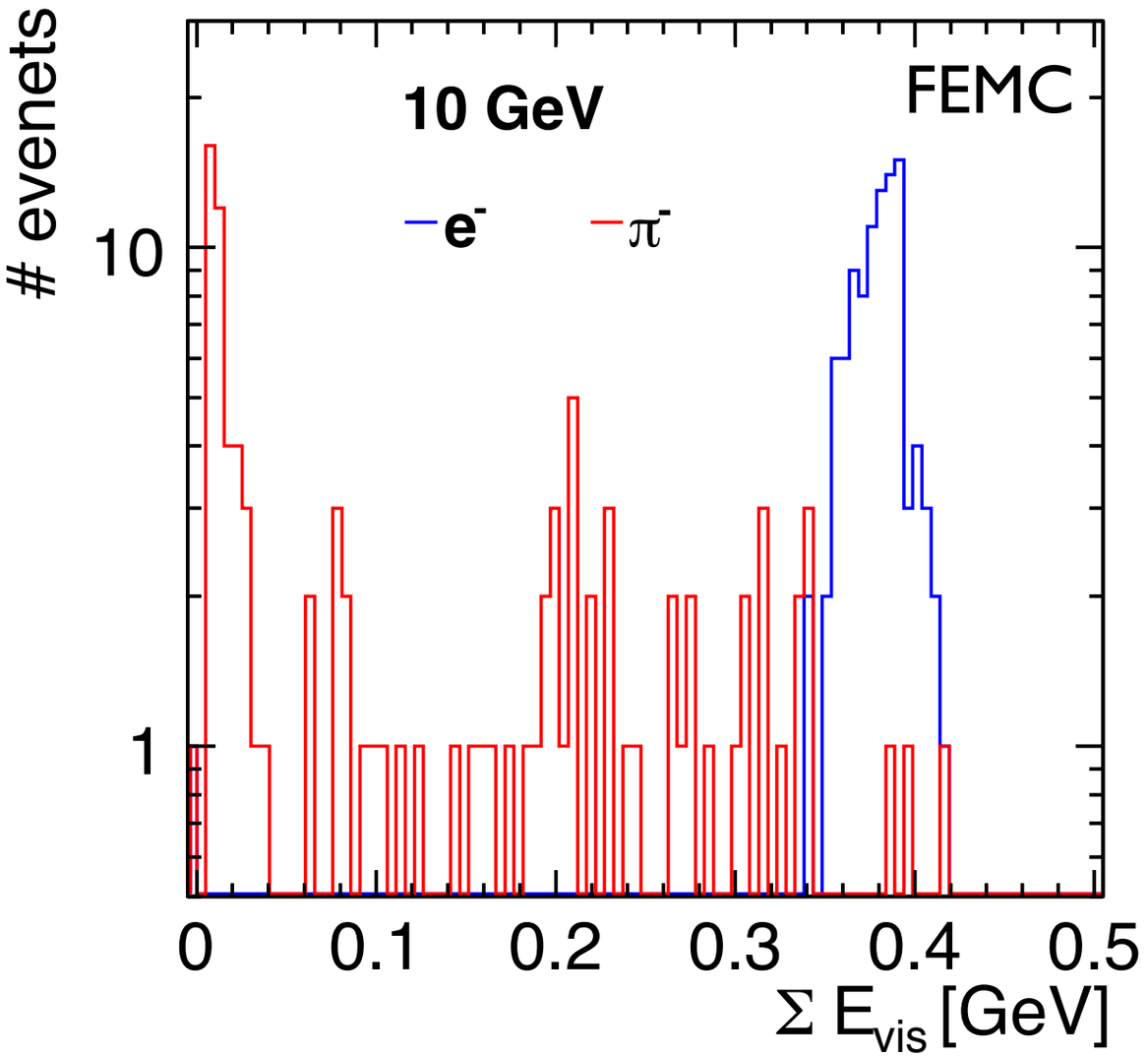
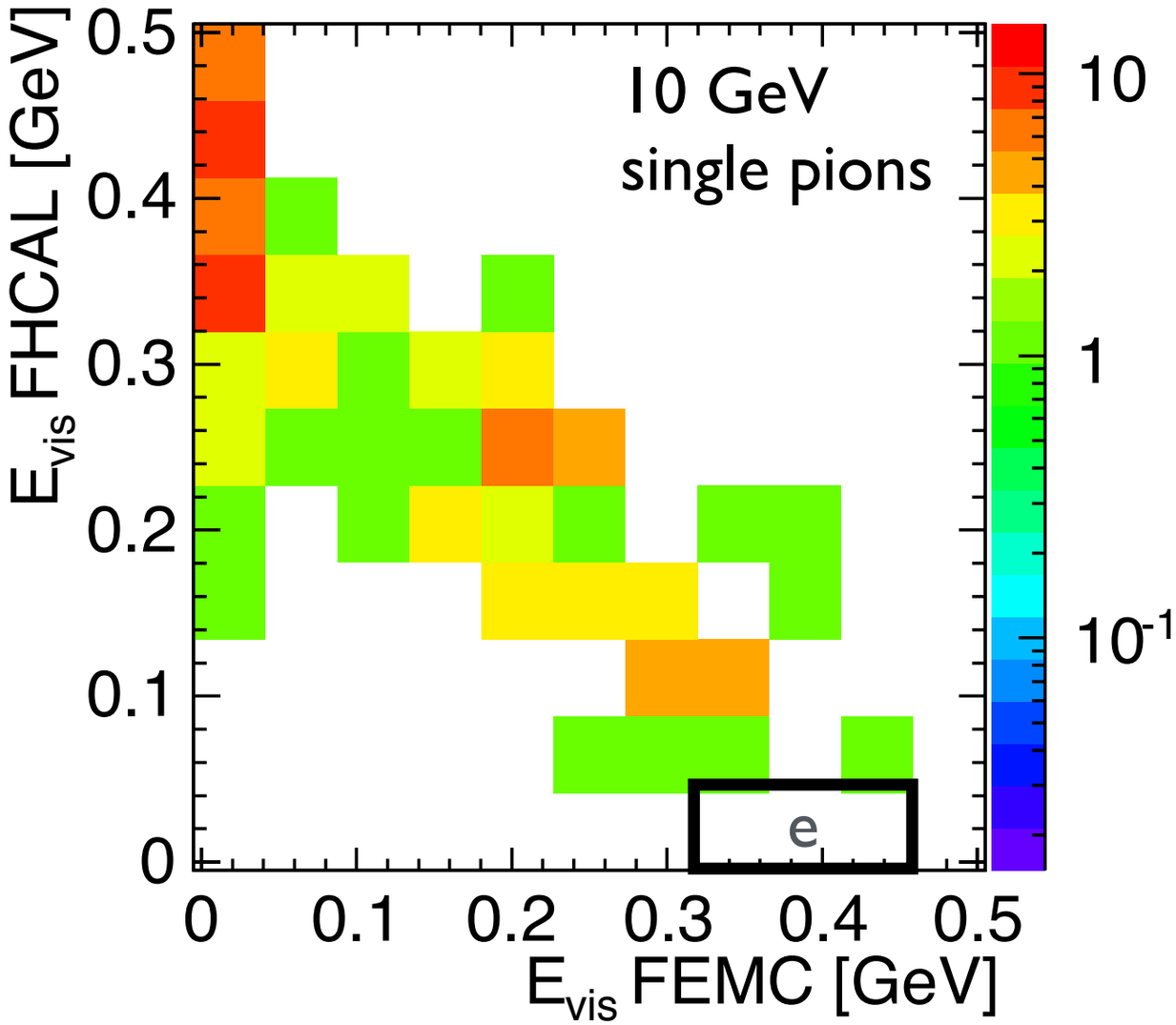
Calorimeter in e-going Direction: Sanity Check





Calorimeter in h-going Direction: Sanity Check



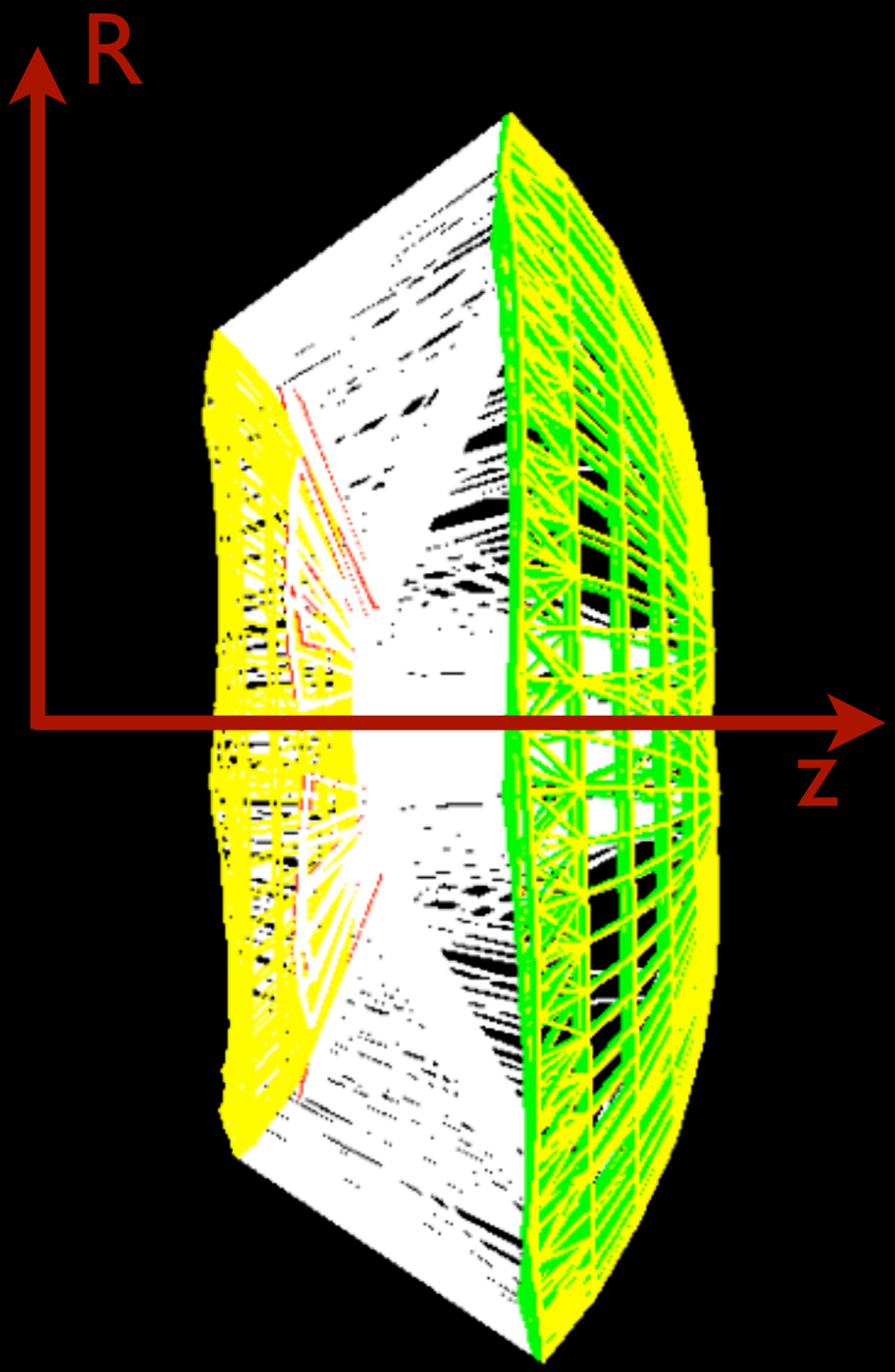


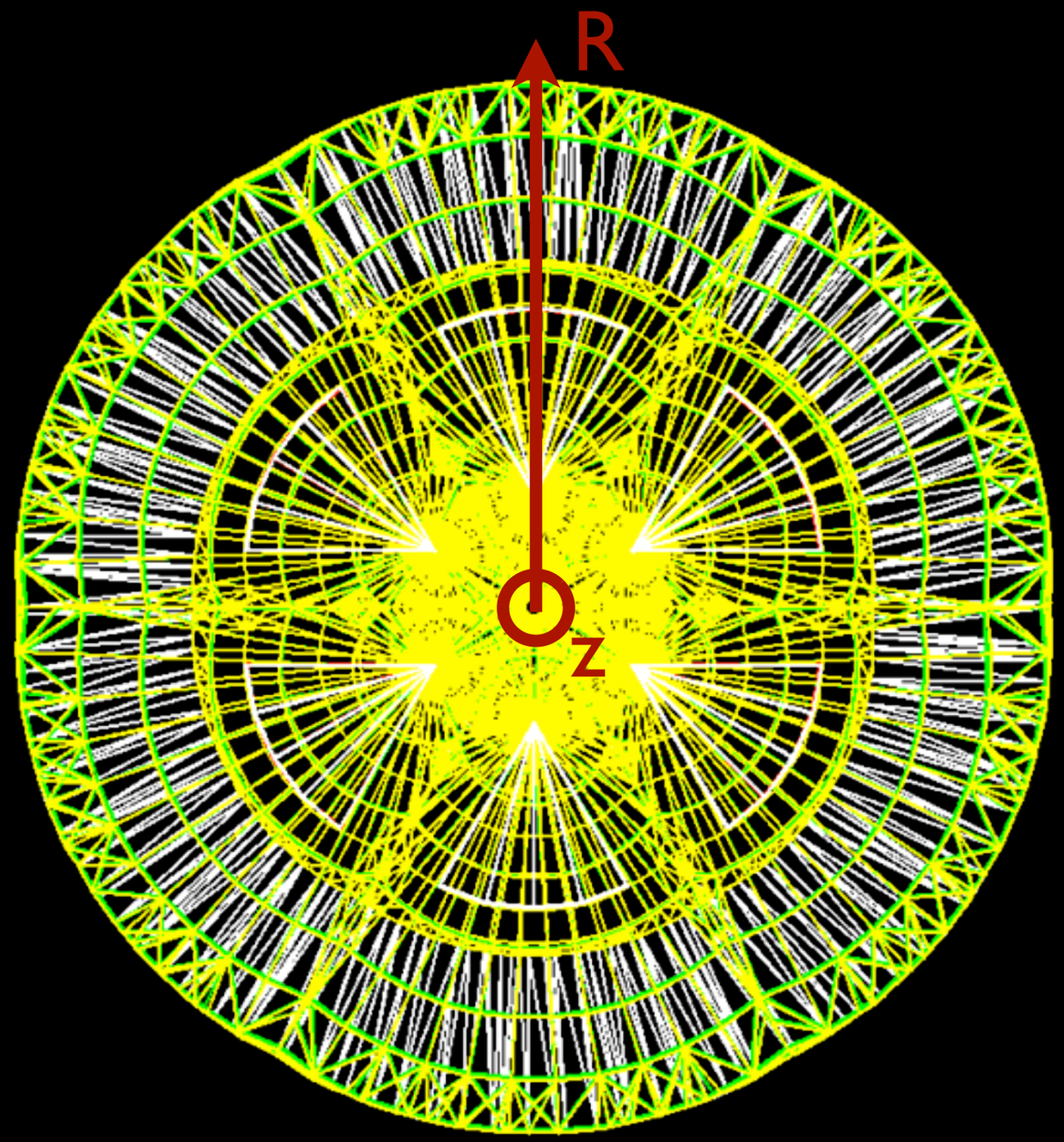
FEMC (Scintillator-Lead, 12%/$\sqrt{E}$): 16752 tower (3 x 2.3 cm - 3 x 5.4 cm)
FHCAL (Scintillator-Steel, 100%/$\sqrt{E}$): 696 tower (18 x 6.8 cm - 18 x 25.7 cm)

Next Steps

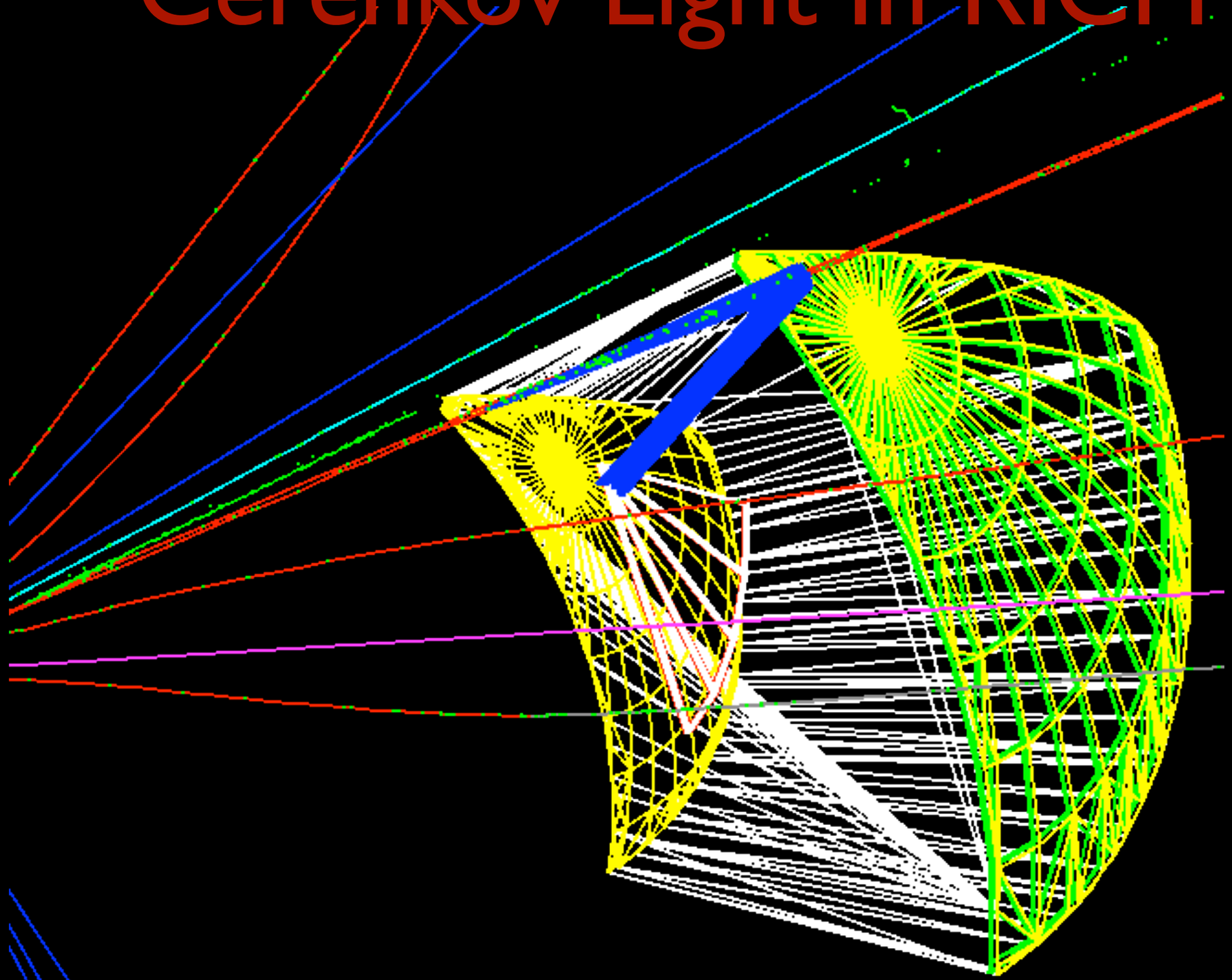
- Implement ‘digitization’ step (Poisson photon statistic)
- Test clustering algorithm for calorimeter tower (try to use jet finding algorithm with adjusted parameters)
- Evaluate electron / pion separation
- Implement more ‘realistic’ detector volumes for calorimeters in Geant4

Gas RICH in GEANT4

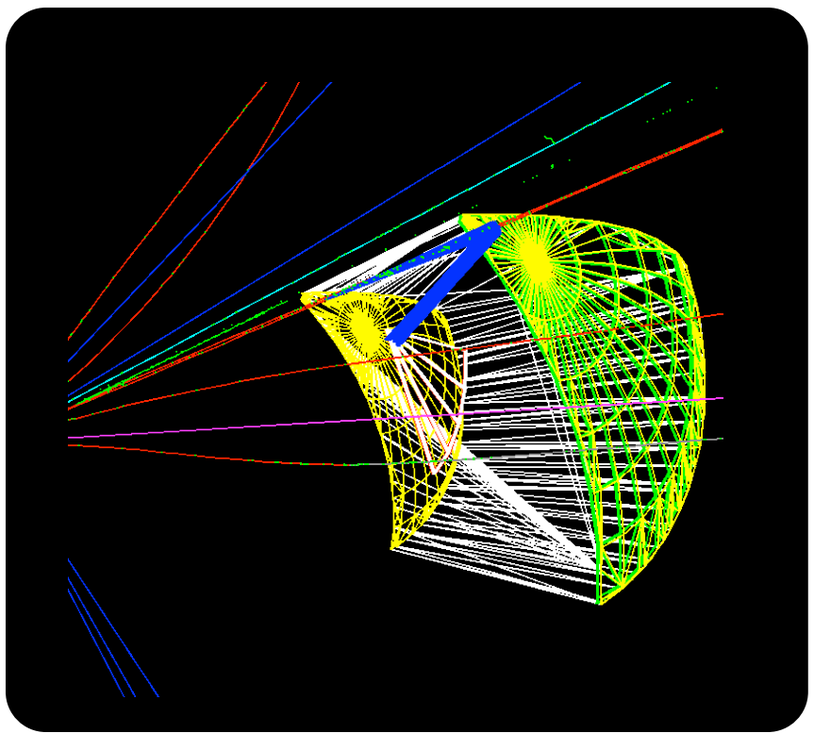


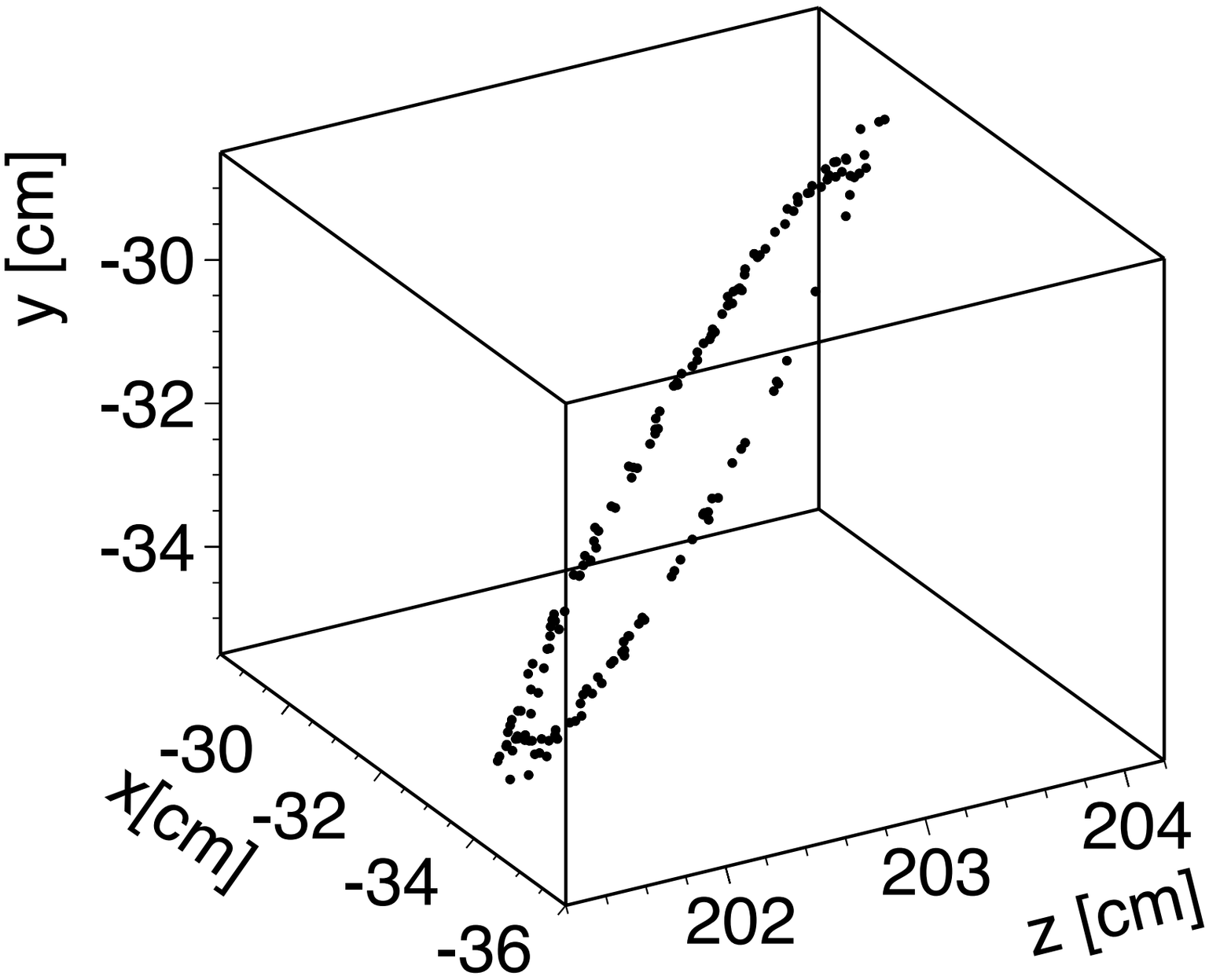


Cerenkov Light In RICH



True MC 'Signal': 3D Positions of all photons reaching the photocathode



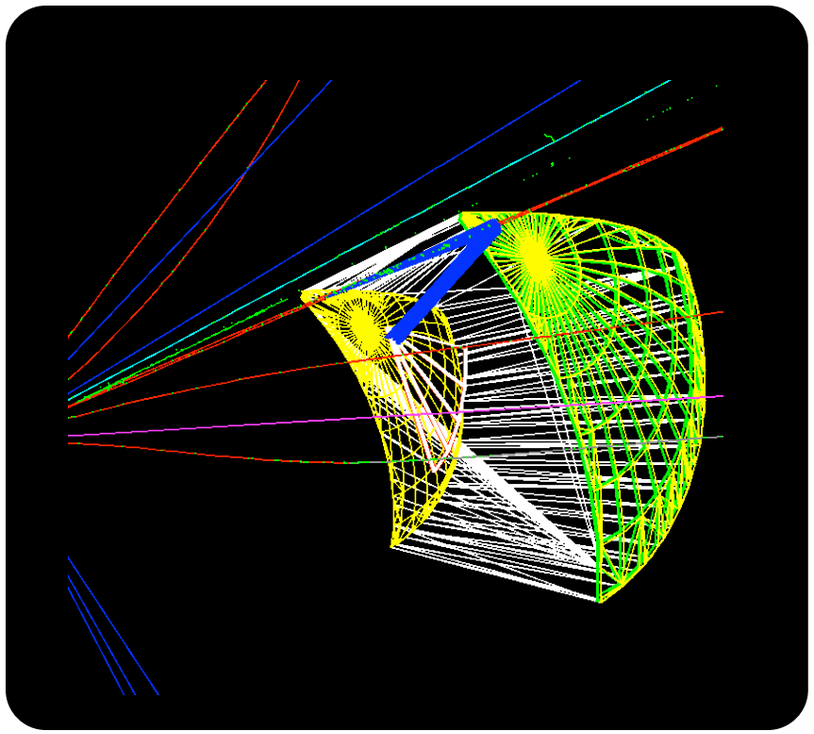


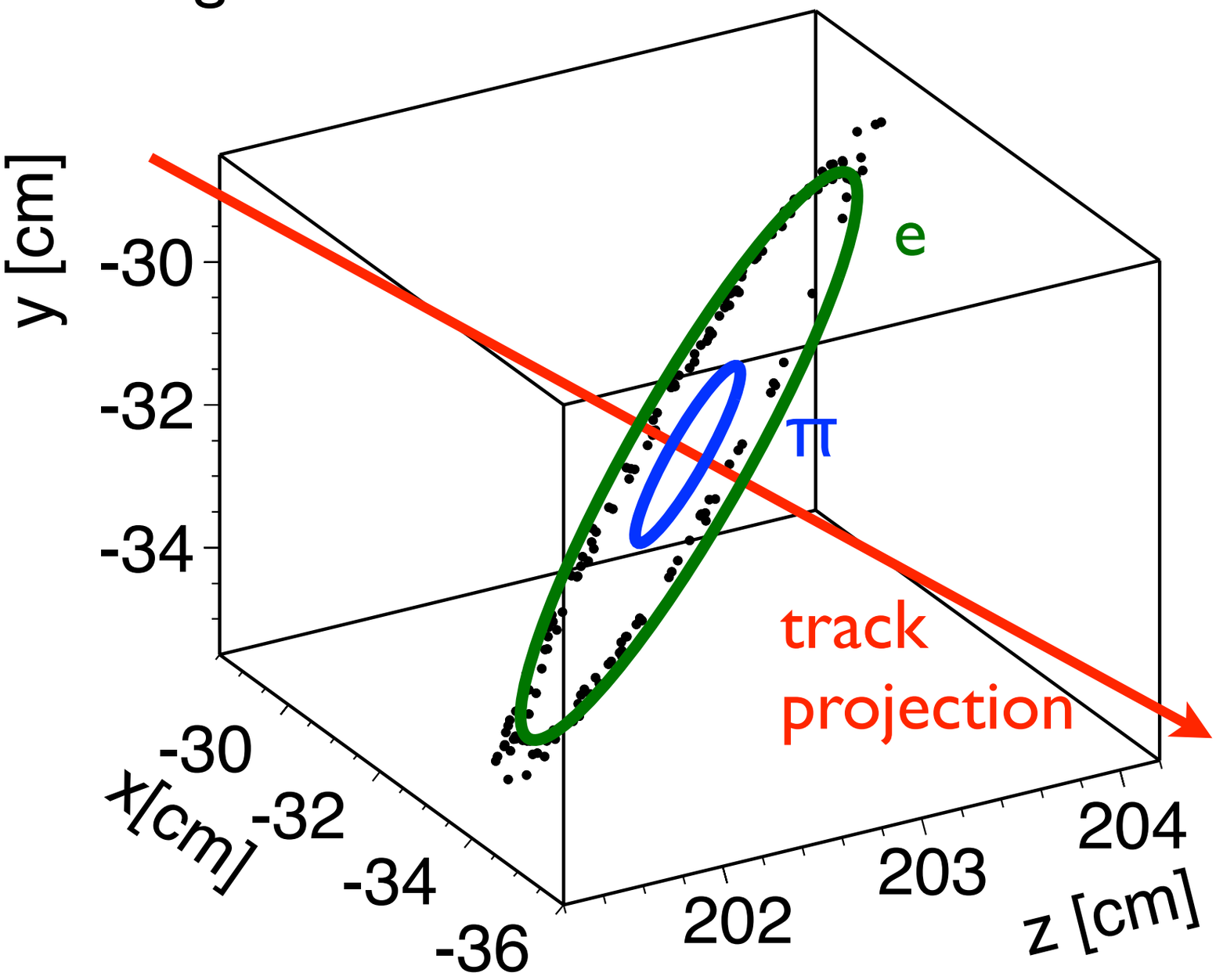
Only Cerenkov photons-
No Scintillation yet

Approach for Analysis Library

Known: Particle track, momentum and ID candidates

➔ count hits in ‘ring candidate areas’ for PID





Additional GEANT4 Studies

- Tracking performance at high rapidities
- Combined momentum resolution of Tracker and Calorimeters
- DIRC (barrel)
- Aerogel RICH (h-going)
- TOF (h-going)

Our Current Simulation Efforts

- Meeting: https://indico.bnl.gov/categoryDisplay.py?categId=93
  Joint EIC detector / fsPHENIX meeting (BlueJeans) every other Tuesday 9 pm EST; **Next: March 10, 2015**

- Weekly meeting with students at Stony Brook

- Mailing list: eic@stonybrook.edu
  (eMail to nils.feege@stonybrook.edu to subscribe)

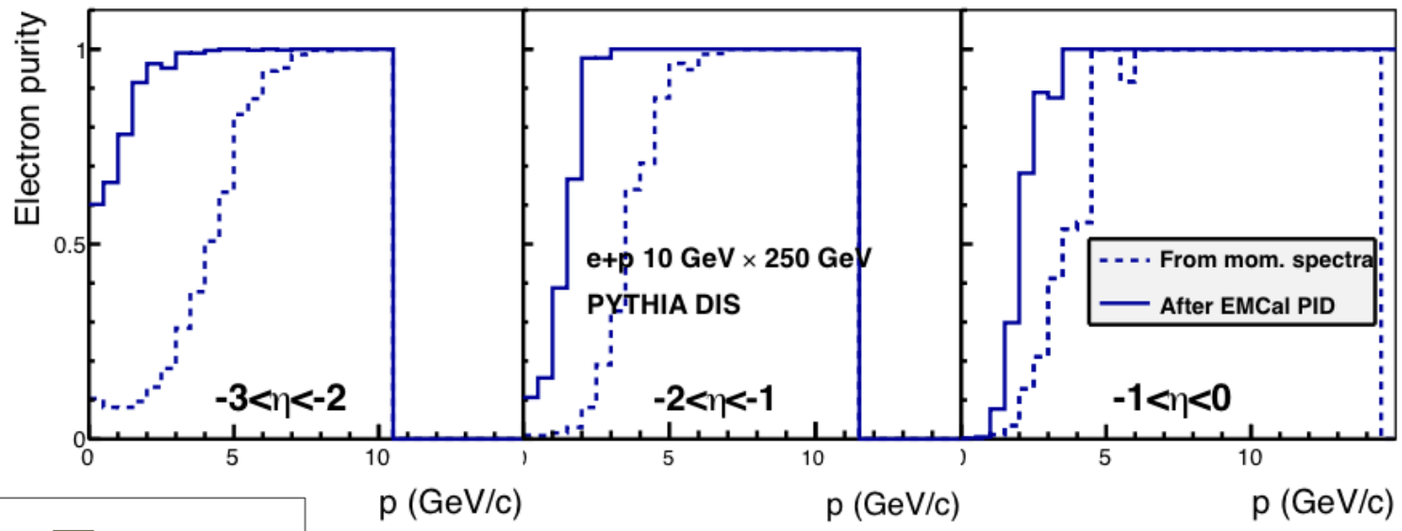
- PHENIX internal mailing list: phenix-ephenix-l@lists.bnl.gov

- Wiki: http://skipper.physics.sunysb.edu/~wiki/doku.php?id=eic:eic

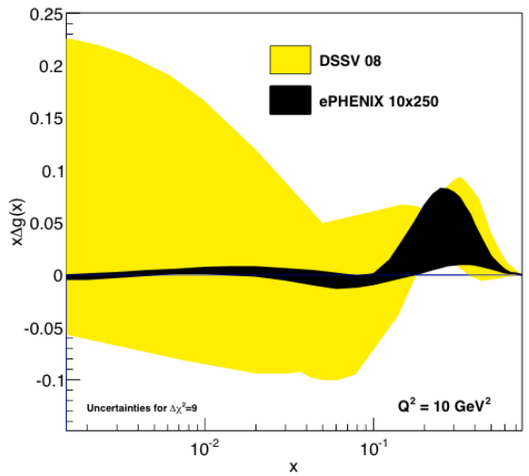
Summary

- ✤ HCAL (yoke) design ephenix_v1 looks promising- COMSOL field map available.

- ✤ Current goals for GEANT4 studies:
  - Calorimeter PID (electron / pion separation) in e+p DIS



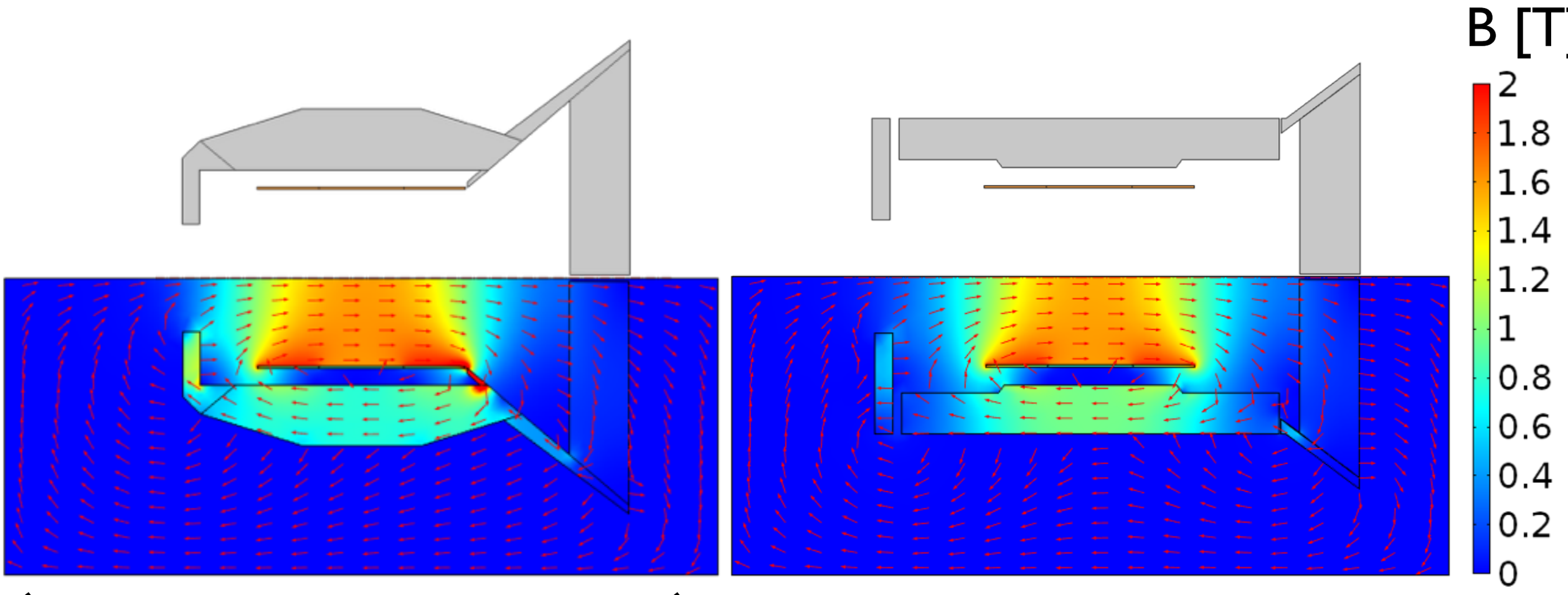
  - Projected uncertainty on longitudinal gluon spin



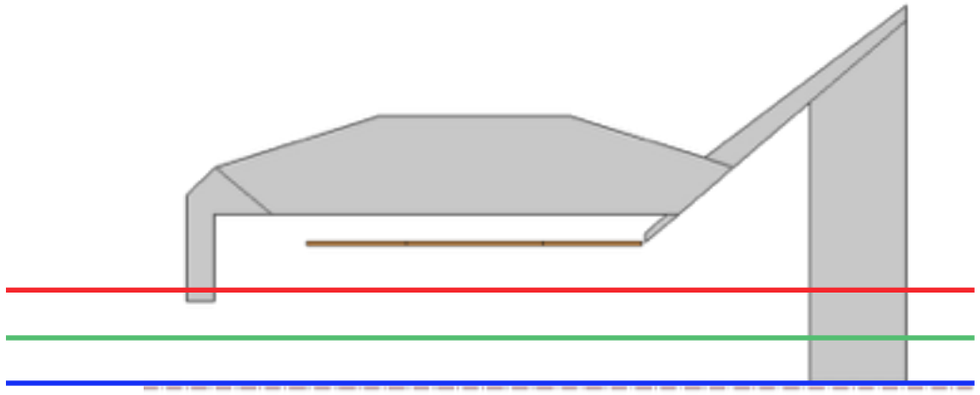
Modular GEANT4 simulation of an EIC detector built around the BaBar solenoid is continuously progressing and already in a good shape for various studies.

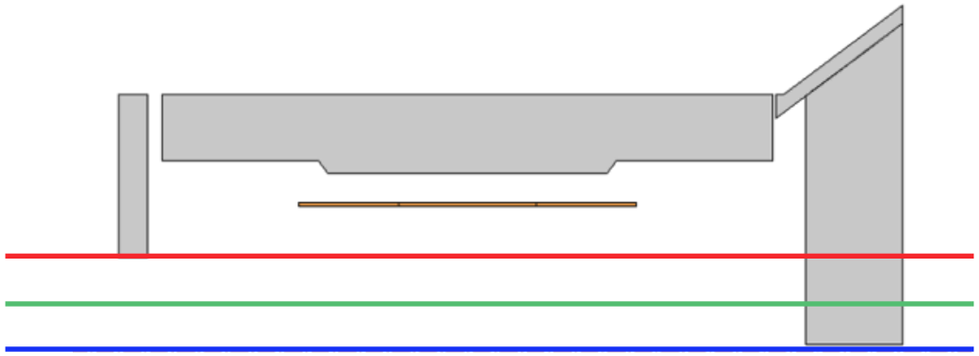
ADDITIONAL SLIDES

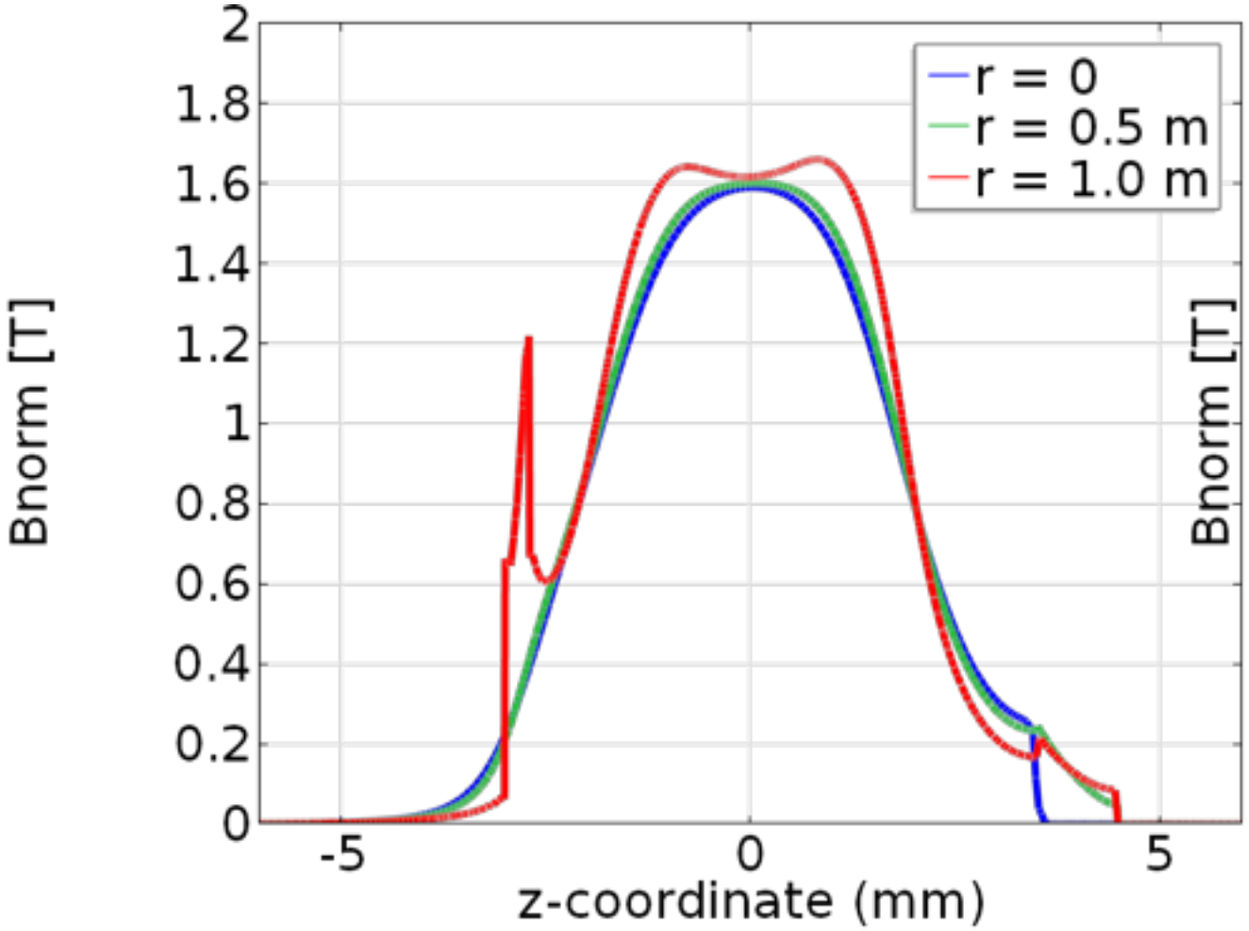
Magnetic field in COMSOL

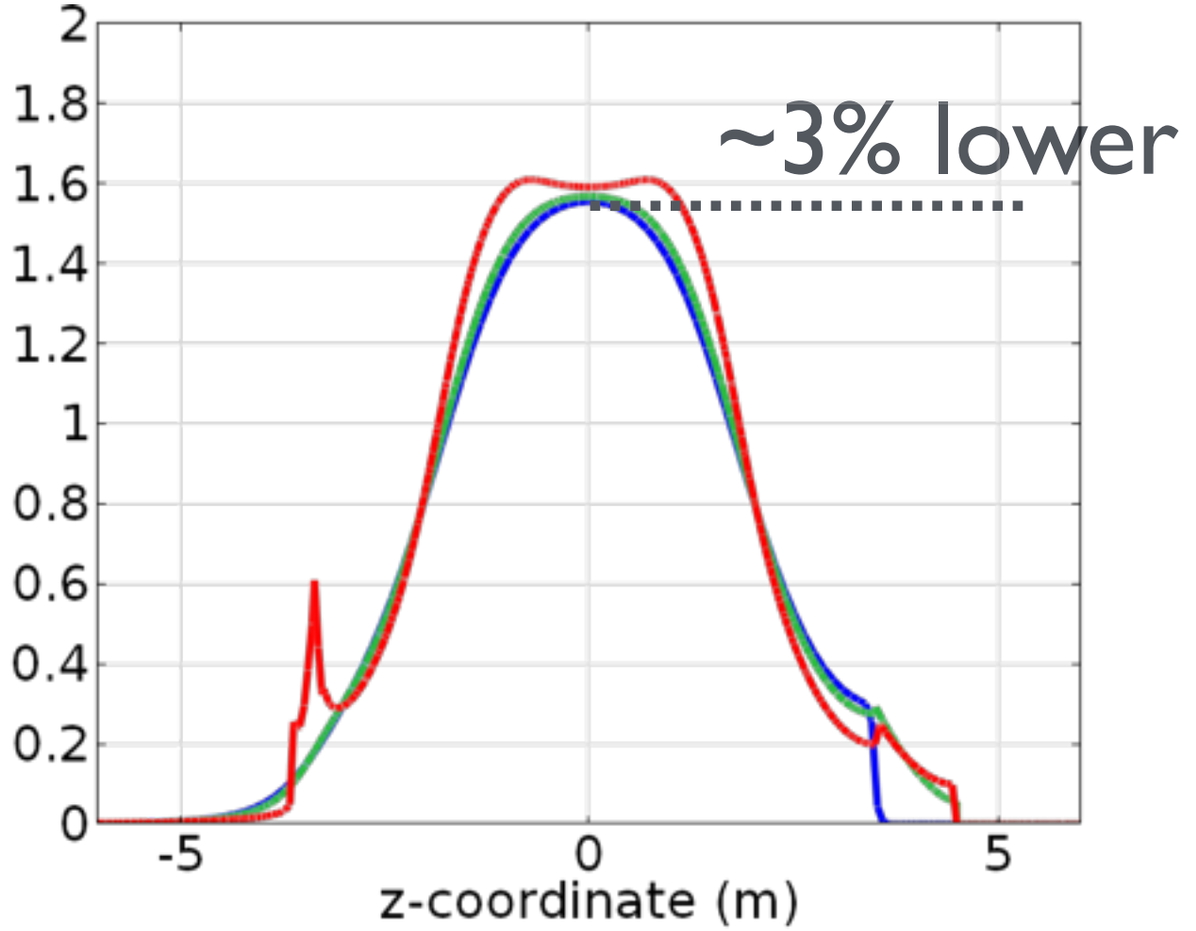


Magnetic field comparison

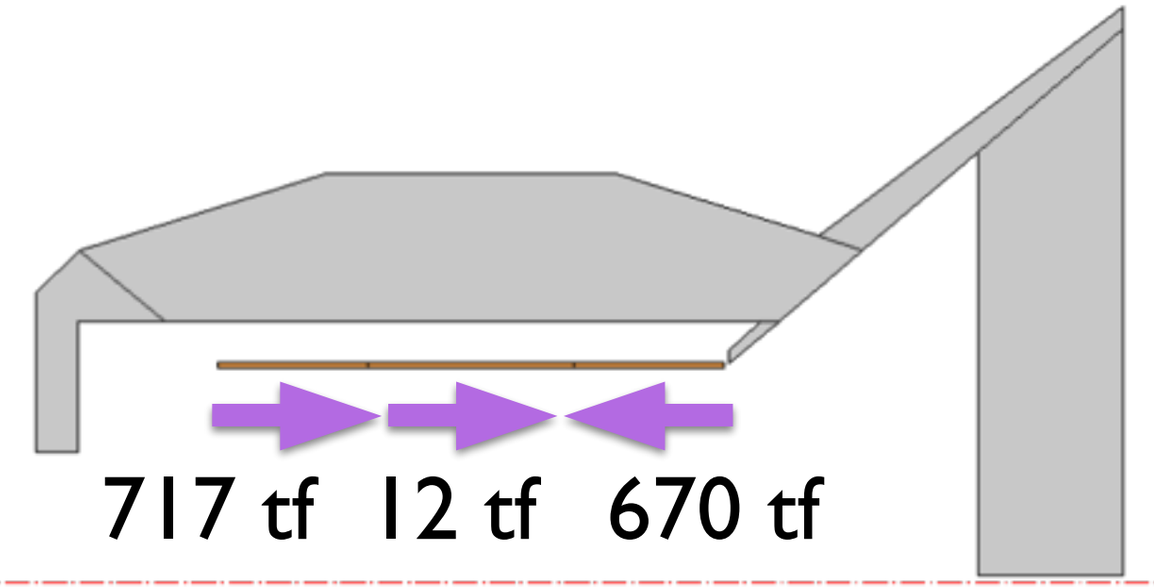




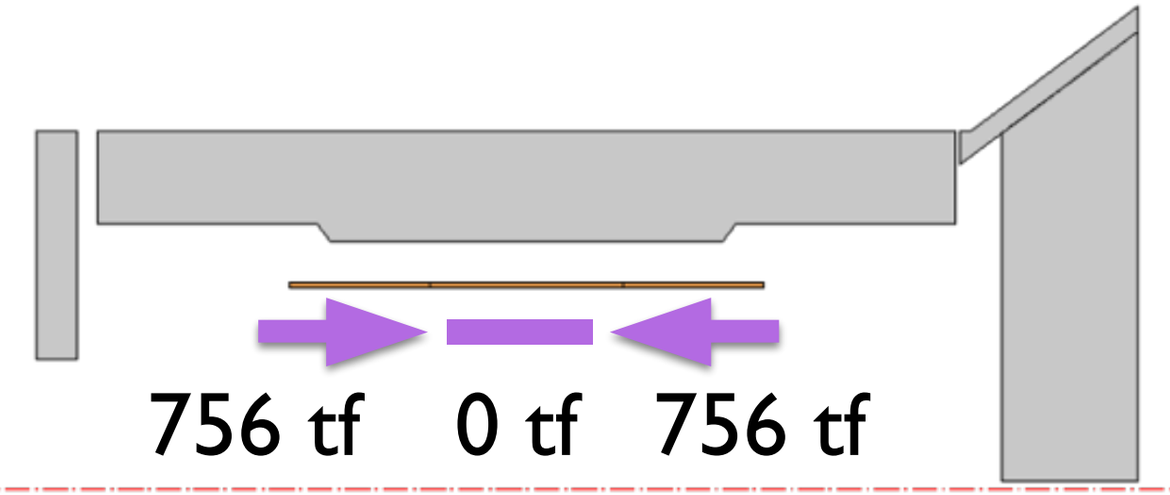




Magnetic forces on magnet coil

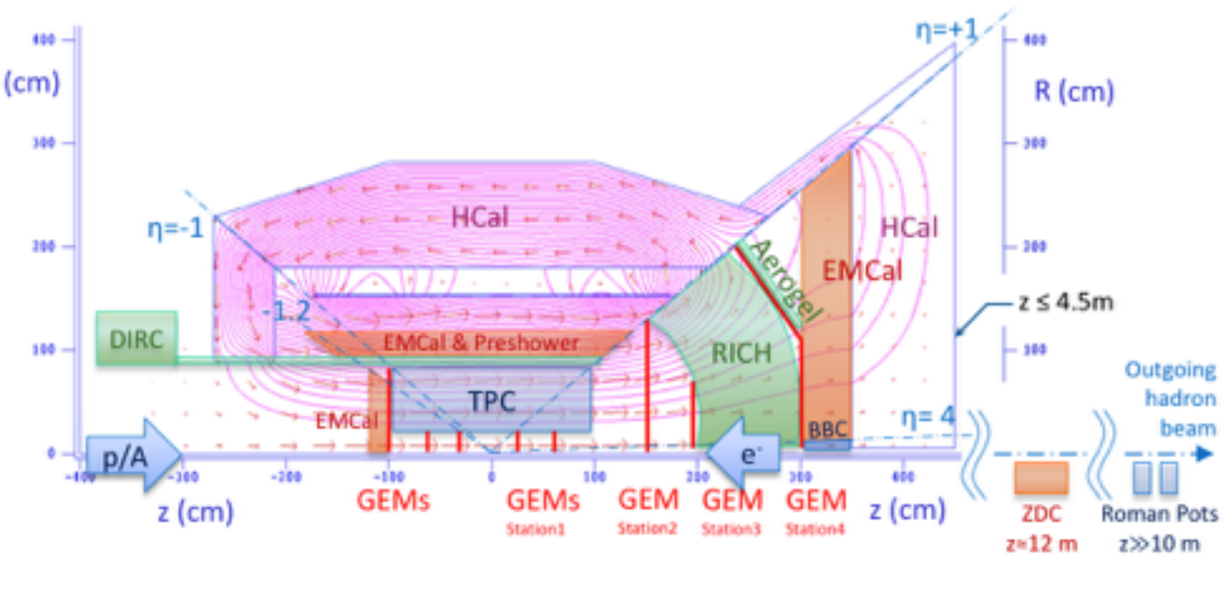


Unbalanced



Balanced

Calorimeter Systems



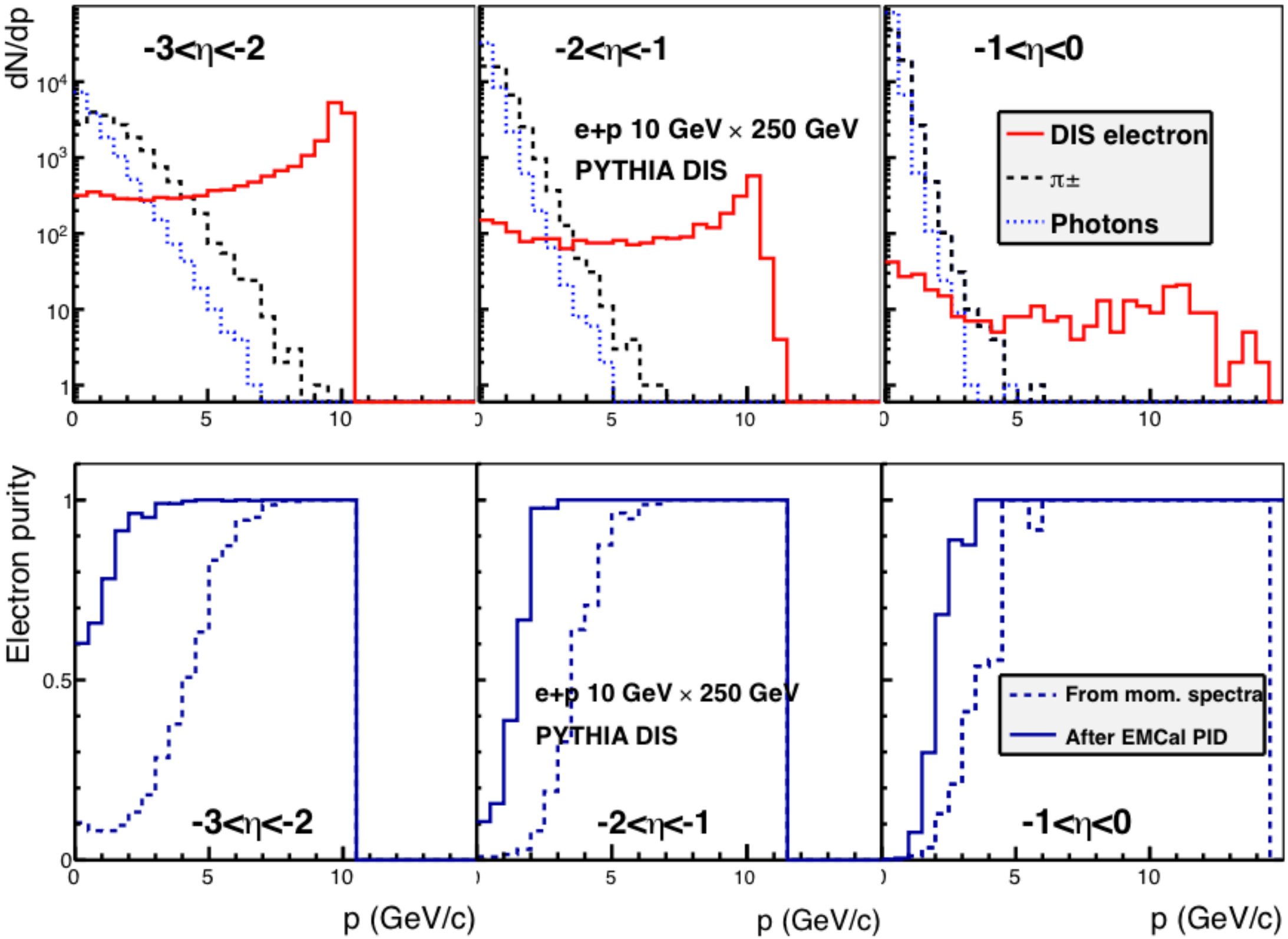
Barrel (sPHENIX):
EMCal: Scintillator-Tungsten, 12%/sqrt(E)
HCal: Scintillator-Steel, 100%/sqrt(E)

e-going:
EMCAL: Lead-tungstate (PWO), 1.5%/sqrt(E)

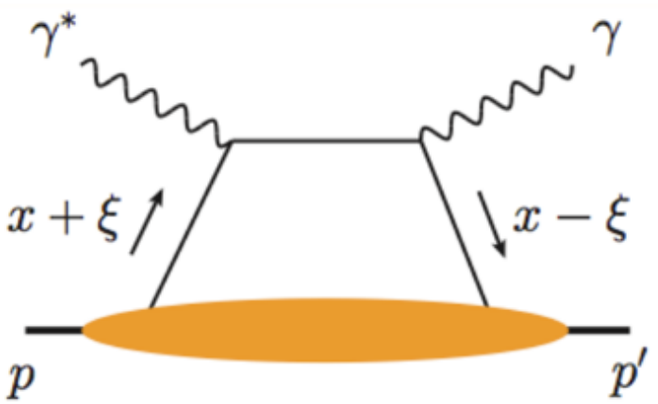
h-going:
EMCAL: Lead-scintillator, 12%/sqrt(E)
HCAL: Scintillator-Steel, 100%/sqrt(E)

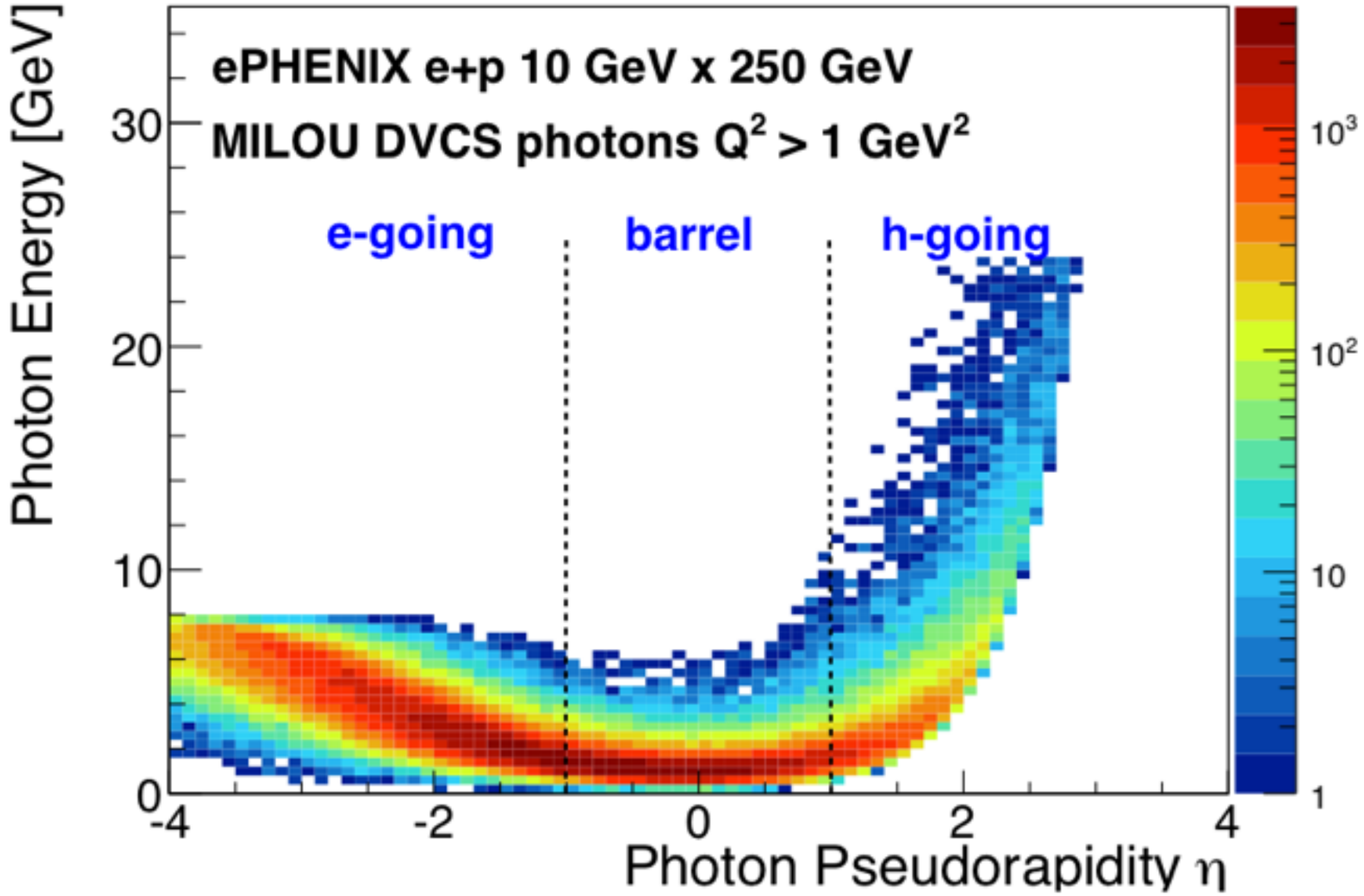
Questions to Geant4:

- Effect of different calorimeter responses to different particles on PID?
- Effects of Bremsstrahlung and photon conversion on backgrounds and efficiencies?
- Resolution gain from combining tracker and calorimeter information?
- Optimization of calorimeter acceptance and segmentation?


dN/dp
-3<η<-2
-2<η<-1
-1<η<0
e+p 10 GeV × 250 GeV
PYTHIA DIS
DIS electron
π±
Photons
Electron purity
From mom. spectra
After EMCal PID
p (GeV/c)

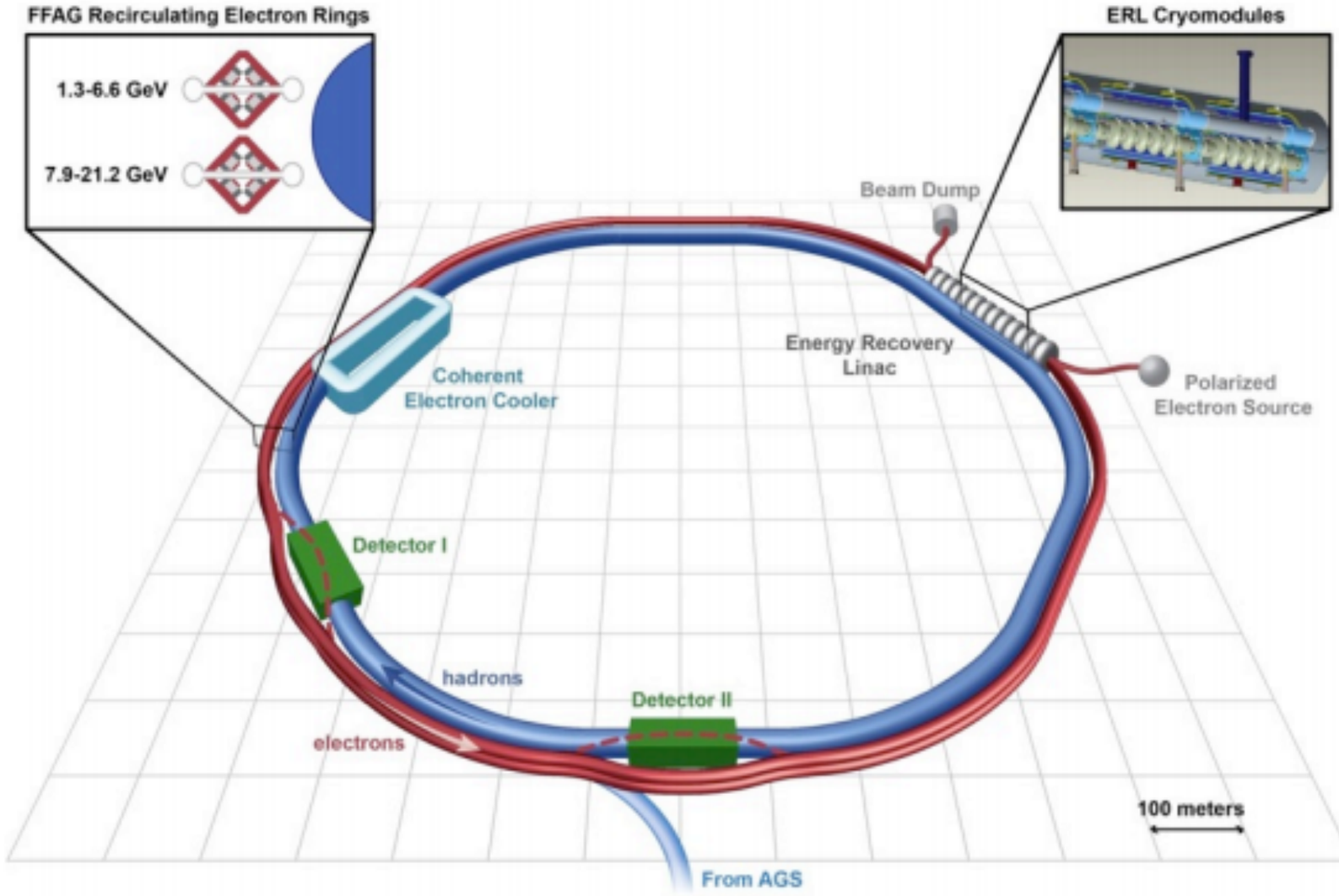
Exclusive Measurements (DVCS)





eRHIC

ep/eA



In current design:

Energy:

Electron: 6.6–21.2 GeV
Proton: 25–250 GeV
Ions: 10–100 GeV
√s: up to 145 GeV

Polarization:

Electrons: 80%
Protons and He3: 70%

Luminocity:

$>10^{33}$ cm^{-2} s^{-1}

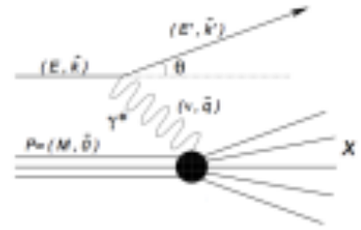
… Still evolving

EIC Detector Concept

Inclusive DIS and scattered electron measurements

With focus in e-going direction and barrel

High resolution EMCal and tracking; minimal material budget

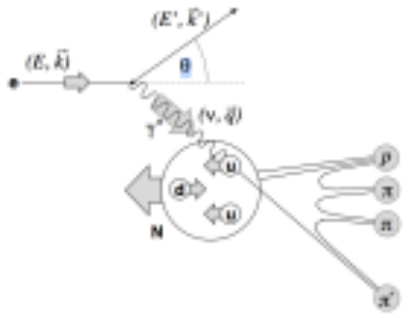


Semi-inclusive DIS and hadron ID

With focus in h-going direction and barrel

Barrel: DIRC for p_h<4 GeV/c

h-going direction: aerogel for lower p_h and gas RICH for higher p_h

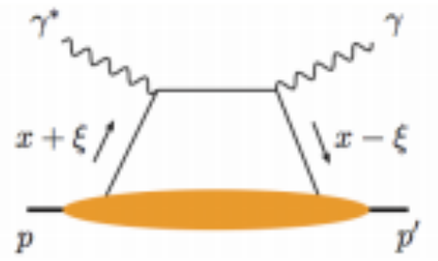


Exclusive DIS (DVCS etc.)

EMCal and tracking coverage in -4<η<4

High granularity EMCal in e-going direction

Roman Pots in h-going direction



Diffractive

Rapidity gap measurements: HCal in -1<η<5; EMCal in -4<η<4

ZDC in h-going direction